General

Anatomical and surgical considerations of the pectoralis muscle

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Introduction

The pectoralis major (PM) muscle is the largest and most superior muscle of the anterior chest wall. The PM plays an important role in flexion, adduction, and internal rotation of the arm. The pectoralis major's size, strength, and anatomical location make it an excellent candidate in transfer surgeries due to its ability to restore balancing forces that may be lost in scapular winging and subscapularis tears. Each of these injuries and pathologies involves the PM muscle in some way, and careful consideration of its anatomy and physiology is necessary. This review article aims to provide a comprehensive overview of the anatomy, physiology, and surgical considerations of the pectoralis muscle with a specific focus on the surgical techniques involving the muscle.

Methods

A comprehensive literature search using a combination of the following terms: pectoralis major, rupture, transfer, chronic subscapularis tear, pectoralis surgery, anatomy, scapular winging, and long thoracic nerve anatomy. There were no limitations with regards to article type or publishing date, but article language was limited to only English.

Conclusion

The pectoralis muscle is an important muscle when it comes to function of the upper extremity primarily or through transfer procedure. Injuries and impairments of the pectoralis major or other muscles of the upper extremity can significantly impact an individual's quality of life, limiting their ability to perform activities of daily living. A thorough understanding of anatomical, functional, and surgical purposes of the pectoralis muscle is crucial for achieving optimal outcomes and avoiding complications.

1. INTRODUCTION

The pectoralis major muscle is a large muscle of the upper extremity that consists of two heads. The clavicular head originates from the medial half of the clavicle and the sternal head originates from the 2nd to 6th ribs, the costal margin of the sternum, and the external oblique aponeurosis.[1] Both heads run from their origins to insert in the upper part of the humerus typically around 11 mm lateral to the biceps tendon known as the lateral lip of the bicipital groove. Both muscle heads twist and converge into a broad and flat tendon, with an anterior layer formed by the clavicular head and a posterior layer formed by lower portions of the sternal head. The PM receives dual innervation of the medial and lateral pectoral nerves.[1,2] The PM plays a significant role in upper extremity strength and mobility, contributing significantly to internal rotation, flexion, and adduction of the humerus.[2] Anatomical and surgical considerations involving the PM muscle include pectoralis major muscle ruptures, subscapularis tears, scapular winging, and Poland syndrome. In each condition, the PM muscle may be the primary muscle of involvement or may play an important role in surgical management. Functional similarities between the PM muscle and the subscapularis muscle make it an effective candidate for surgical repairs of subscapularis tears.[3] Additionally, in cases of scapular winging, the strength and size of the PM muscle make it a favorable candidate to replace the serratus anterior and restore scapular functioning.[4] In Poland Syndrome, patients present with chest wall hypoplasia and pectoralis major agenesis that results in significant anatomical and functional issues.[5] The conditions presented above all require an understanding of the anatomy of the pectoralis major muscle as well as its role in surgery in order to properly treat and assess individuals affected by the various conditions.

2. METHODS

A comprehensive literature search using a combination of the following terms: *pectoralis major, rupture, transfer,*

chronic subscapularis tear, pectoralis surgery, anatomy, scapular winging, and *long thoracic nerve anatomy.* There were no limitations with regards to article type or publishing date, but article language was limited to only English. Each article was read in its entirety to ensure that the information suited the goals of this review.

3. ANATOMY

The muscles of the pectoral region have a significant role in the utilization of the upper extremities. These muscles, particularly the pectoral muscles, form the connection between the upper extremity and the thoracic walls. Through their actions, they provide force on the humerus, scapula, and ribs. The primary muscles within this group are considered to be the pectoralis major, pectoralis minor, serratus anterior, and subclavius.[6] The largest of this group is the pectoralis major, a fan-shaped muscle directly underneath the breast tissue. The pectoralis major has multiple points of origin: the medial half of the clavicle, anterior sternum, first 7 costal cartilages, and the aponeurosis of the external oblique. These fibers coalesce and attach to the lateral portion of the intertubercular sulcus of the humerus. At this attachment site, there are considered to be two heads of the pectoralis major: the clavicular and sternal.[7] These anatomic landmarks become relevant during surgical procedures utilizing the pectoralis major. The pectoralis major exerts its main functions on the upper extremity through flexion, adduction, and medial rotation at the glenohumeral joint, as well as flexion of an extended arm, and extension of a flexed arm.[7] The primary arterial supply comes from the pectoral artery, arising from the thoracoacromial trunk. Venous drainage begins in the pectoral vein, which subsequently drains into the subclavian vein. Due to its size and significant vascularity, the pectoralis major is frequently used for flap repairs.[7] Nervous supply to the pectoralis major is different between the two heads. The clavicular head is supplied by the lateral pectoral nerve, which arises from the lateral cord of the brachial plexus. The sternal head is supplied by the medial pectoral nerve, originating from the medial cord. The lateral cord travels anterior to the axillary artery and enters the pectoralis major medial to the humeral insertion, while the medial pectoral nerve travels posterior to the axillary artery and inserts into the posterior surface of the muscle.[7] During surgical procedures, it is important to be aware of the surrounding structures and their locations to avoid unintentional injury.

The pectoralis minor is located directly posterior to the major, and is significantly smaller. This muscle originates from the third through fifths ribs, traveling superolaterally before inserting onto the medial and super aspects of the coracoid process. The primary function is to stabilize the scapula against the thoracic wall. Arterial supply is also provided by the pectoral artery, with nervous supply also provided by the lateral and medial pectoral nerves.[6] The serratus anterior functions primarily for protraction of the scapula. It originates from the outer portion of the first through eighth ribs, and inserts into the medial scapular margin. Multiple arteries supply the serratus anterior, including the lateral thoracic, super thoracic, and thoracodorsal arteries. It is innervated by the long thoracic nerve, which arises from the C5-C7 brachial plexus roots.[6] The subclavius originates from the first rib and inserts onto the clavicle at the subclavian groove. It both depresses the shoulder and elevates the first rib, helping to protect the brachial plexus and subclavian vessels. Arterial supply is from the clavicular branch of the thoracoacromial trunk, and nervous supply is from the subclavian nerve.[6]

4. ACUTE PECTORALIS TEARS

Acute tears of the pectoralis muscle are uncommon injuries that most commonly occur in men between the ages of 20 and 40.[8] Originally only reported in infirmed and elderly populations, the rising participation of younger individuals in weightlifting activities and athletics have caused an increased incidence of pectoralis tears in this population.[9] In a study that recorded 655 cases of pectoralis tears and the activity that caused them, the most common causes included bench-pressing (53.4%), intensive sports such as skiing and wrestling (35.4%), and finally trauma unrelated to sports or weightlifting (11.1%).[8] The muscle can tear along any point in its anatomy including at its insertion, origin, the musculotendinous unit/muscle belly, or within the tendon itself. The most common site of injury is an avulsion at its insertion at the humerus.[8] It is suspected that bench pressing is a common mechanism of injury due to the arm being in a position of extension, abduction, and external rotation, which causes excessive lengthening and stress which makes the muscle particularly susceptible to tears.[8,9]

4.1. CLINICAL PRESENTATION

Clinical presentation of acute pectoralis tears is typically swelling and bruising along the anterolateral chest wall and/or upper arm following an injury or “popping” sensation of the muscle. A complete tear may result in loss of the axillary fold due to retraction of muscle medially which can also cause decreased nipple height relative to the uninjured side.[8-10] The Cruciform Test can be used as an adjunctive physical exam test, in which the patient is placed in supine position and is asked to maintain each elbow in extension and shoulder at 90 degrees of abduction. The examiner instructs the patient to adduct each arm towards the midline, and if either arm is unable to lift due to pain or lack of strength, a tear of the pectoralis major muscle may be present.[10] Hypertrophy of the fascia of the pectoralis muscle can occur in complete and high-grade tears, resulting in a thick cord-like structure that can be palpable between the humeral insertion and the retracted tendon. Tears may often be masked or difficult to diagnose clinically due to a hematoma, incomplete tear, or intact fascial covering.[9] Thorough evaluation of the neurovascular system of the extremity should also be performed. Clinical diagnosis may be even more challenging for overweight patients or patients with subacute/chronic tears. It is thereby impor-

tant to elicit a detailed history and comprehensive exam in order to accurately assess subsequent diagnostic and treatment options.

4.2. IMAGING

Radiographic evaluation allows for definitive diagnosis, usually with an ultrasound or magnetic resonance imaging (MRI). An ultrasound is usually a cost-effective and easily accessible option, and can be used to identify the locations of the sternal and clavicular heads of the pectoralis major muscle. However, evaluation of injuries is highly dependent on the experience and skill of the sonographer and can leave a lot up to interpretation.[11] Acute hemorrhages will appear hypoechoic but as they become hematomas they will display on ultrasound with heterogeneous echogenicity. Retraction of the tendon combined with hematoma formation will oftentimes localize to the space between the coracobrachialis and deltopectoral groove.[9,11] Chest MRI is a more definitive and accurate radiographic imaging test that can better visualize the soft tissue structures including localization of the tear, edema, hematomas, hemorrhages, retracted tendon or adhesions. MRI is considered the gold standard imaging technique, but in acute tears the nature and location of injury may be difficult to localize due to edema and hemorrhage. Chronic tears may be more characterized by fibrosis, adhesions, atrophy of the retracted muscle, and scarring.[11]

4.3. SURGERY

Surgical management is the definitive treatment for acute and chronic tears of the pectoralis major muscle. Conservative non-operative management may be reserved for elderly patients or those unfit for surgery, but is not the preferred method of treatment as patients will not regain the strength and functionality of the muscle. Surgical repair is often the treatment of choice due to improved patient satisfaction, cosmesis, and strength, as well as an earlier time to return to sporting activities.[11]

Repair and reconstruction are the two primary options for pectoralis major ruptures, with chronic tears most often requiring reconstruction due to adhesions, scarring, fibrosis, and retraction/atrophy of the muscle and tendon.[8] Techniques for autografting use of the Achilles tendon, tensor fascia lata, semitendinosus, patellar tendon, and bone-patellar tendon-bone. Dermal allograft may also be used.[8,9] These grafts may be used as a bridge to reconnect the retracted tendon to its insertion site at the humerus. New techniques use a semitendinosus allograft woven into the muscle belly of the pectoralis major to provide a stronger and more profound tendon.[11]

The three main techniques for repair of the pectoralis major at the tendo-osseous junction include transosseous suture (TOS) with the possible addition of a bony trough, suture anchors, and cortical button fixation. The TOS technique involves drilling holes lateral to the insertional footprint of the pectoralis major on the humerus. After suturing through the tendon, it is pulled through two sets of drill holes and then tied down to the lateral cortical bone bridge.[11] A modified version of this technique involves creating a vertical trough where the pectoralis major was once inserted, and drilling holes lateral to this trough. Once sutures are placed through the retracted tendon, they are passed into the trough and through the drill holes which are then eventually tied over the bone bridge.[12]

In the suture anchor technique, preloaded high-strength anchors with nonabsorbable sutures are placed into the insertional footprint of the pectoralis major muscle at the humerus. Sutures are then passed through the tendon and are tightened to allow for approximation and fixation of the tendon to its original insertion.[11,12]

In the cortical button technique, holes are drilled over the humerus at the insertional footprint of the pectoralis major muscle. Special buttons preloaded with sutures are placed into the holes. The sutures are run through the tendon and pulled to shuttle both heads of the pectoralis major tendons back onto its insertion site at the humerus.[12,13]

Sutures used are typically absorbable and high-strength, with Krackow, Kessler, or Mason-Allen techniques used for locking them down when threaded through the tendon or muscle.[12] Cadaveric studies comparing the three techniques showed limited evidence for the superiority of one repair technique to the author, although the majority of repairs failed at the tendon-suture interface. Current research suggests that nonabsorbable sutures of greater caliber and larger surface area may provide better pulling strength and durability at the suture repair interface.[8] A study by Bodendorfer et al. demonstrated that complication rates of acute repair was 10.62% in acute repairs compared with 1.78% in chronic repairs. However, acute repairs resulted in better functional outcomes and patient satisfaction with regards to pain levels and cosmetics.[14] The increased complication rate in acute repair is due to the statistic being a sum of complications (neuropathy, persistent pain, rerupture, and hematoma) as opposed to the single reported complication of infection.[14] Choice of surgical technique depends on the extent of the injury and surgeon preference and ability. Overall, pectoralis major ruptures are rare injuries that may be complex, requiring a comprehensive evaluation of the patient's needs and abilities in order to tailor the proper treatment and surgical technique to restore function and alleviate pain.

5. SUBSCAPULARIS TEARS

The rotator cuff is a crucial anatomical structure, providing stabilization of the glenohumeral joint via compression of the humeral head against the glenoid. However, this structure is also frequently injured in the general population. Though injuries to the supraspinatus are most common, injuries to the remaining muscles may also occur. The subscapularis is the largest and strongest muscle of the rotator cuff, providing approximately 50% of the total force.[15] The muscle arises from the subscapular fossa and forms a tendon inserting on the lesser tubercle of the humerus.[16] The primary function of the subscapularis is internal rotation of the humerus, the only rotator cuff muscle with this function. It additionally provides assistance with adduction and

extension, along with preventing anterior humeral dislocation.[16]

5.1. PATHOLOGY

Tendonitis is a minor, treatable concern in regard to the subscapularis. This typically results due to repeated contact with the coracoid process. This is frequently seen in overuse, often in overhead throwing athletes. As this becomes chronic, the tendon can begin to remodel.[16] However, the primary concern is tears of the subscapularis tendon. Though it has been estimated that over 27% of rotator cuff tears include a tear of the subscapularis, isolated tears only compose 6.4-10% of all tears.[17] Tears typically occur secondary to gradual degeneration of the tendon. Traumatic tears are often due to a combined hyperextension and external rotation mechanism, often in young males.[16, 17] Tears are also often seen in association with anterior shoulder dislocations. Concomitant biceps tendon injury is frequently seen with subscapularis tears, with prior studies reporting rates from 20% to 90% of tears including pathology of the biceps tendon. Subscapularis tears are most commonly classified via the Lafosse or Lyons systems.[17] Chronic subscapularis tear is a further pathologic concern. This is usually considered a degenerative disease, often with findings of fatty degeneration of the muscle.[18] There have been numerous risk factors evaluated for chronic subscapularis tear, including subcoracoid stenosis and morphology of the coracoid process. A study conducted by Park et al. identified metabolic syndrome as a potential risk factor, along with overuse activity, diabetes, posterosuperior rotator cuff tears, and injury to the biceps tendon.[15] Chronic tears may lead to long standing anterior shoulder pain and weakness in their range of motion (ROM), and are more complicated to manage from a surgical perspective. Subscapularis tears cannot be compensated for as it serves as a force couple to oppose the infraspinatus and teres minor muscles to stabilize the glenohumeral joint. The subscapularis also opposes the upward pull of the deltoid. Surgical fixation of the subscapularis tears serves to restore the tension of the rotator cuff, decrease the strain of the unopposed muscles, and balance the shoulder.[19]

5.2. DIAGNOSIS

Patients with a subscapularis tear will often describe pain in the anterior shoulder following an event of forced external rotation, though this is not specific for subscapularis tear.[17] Tenderness may be present along the lesser tubercle.[16] Evaluation for pain along the biceps tendon should be done, as it is frequently injured along with the subscapularis, as well as examination of the posterosuperior cuff and acromioclavicular joint.[20] This is due to the intimate nature of the biceps tendon with the insertion point of the subscapularis, as the biceps tendon resides in the bicipital groove formed by the lesser and greater tuberosities, the former which serves as the attachment site for the subscapularis. Subluxation, dislocation, or tearing of the biceps tendon may result due to this association in tears of the subscapularis.[20] Patients will frequently report weakness with internal rotation, such as with clasping a bra strap. Physical exams may demonstrate weakness or pain with internal rotation and increased passive external rotation.[17] Special tests for tears of the subscapularis include Gerber's lift-off test and the bear hug test. The lift-off test is performed by having the patient internally rotate the arm and place the dorsum of their hand against their lower back. The test is positive if the patient is unable to lift the hand away from the back. This may also be conducted by having the patient adduct the arm as much as possible with the elbow flexed to 90° and place the palm against the abdomen. The examiner will attempt to pull the hand away, while the patient resists. Weakness as compared to the contralateral side is considered positive.[16] Specifically, the lift-off test has been found to activate the lower subscapularis, while the belly-press test activates the upper portion.[17] The bear hug test is performed by asking the patient to place their hand of the affected arm on the opposite shoulder and resist as the examiner attempts to pull it off. Lifting of the hand by the examiner is considered positive.[20]

Initial imaging of shoulder pain includes plain radiographs. These images are likely to be normal in the case of a subscapularis injury, outside of possible avulsions.[16] The gold standard for diagnosis is considered to be MRI. The ability to diagnose subscapularis tears with MRI is less than other rotator cuff tears, with varying specificities and sensitivities.[17] Overall sensitivity for subscapularis tears ranged from 36-88% while specificity ranged from 90-100%. For rotator cuff tears, sensitivity was around 96% while specificity ranged from 65-100%.[17] Difficulties for proper evaluation of subscapularis tears on MRI are hypothesized to be due to acquisition protocols, tendon analysis, volume averaging of the rotator interval at the superior portion of the subscapularis, and portions of the tendon being poorly visualized.[21] Axial imaging has been found to be most useful in identifying tears, while coronal and sagittal images may help with characterization and extent of tearing. Coronal imaging may also demonstrate a fluid signal medial to the coracoid which may be suggestive of injury to the subscapularis. Axial and sagittal imaging may additionally be used to evaluate the degree of atrophy and any retraction or edema.[20]

5.3. SURGICAL REPAIR

Though conservative management may be indicated for certain populations, including older patients with chronic tears, its success can be limited.[17] The subscapularis has an important role in shoulder stability, and studies have demonstrated that delayed repair can negatively affect the success rate of surgical repair. Therefore, surgical repair should be considered, particularly in younger and more active populations.[22] Arthroscopic repair has provided satisfactory results.

Both methods of repair can provide successful results in primary, uncomplicated subscapularis tears. However, large or chronic tears may often not be repairable in this manner. These tears often have a significant degree of tendon retraction, fatty degeneration, and muscle atrophy.[22] One of the most common methods for this is transfer of the pectoralis major tendon. This technique was first described

by Wirth and Rockwood, in which the upper two-thirds of the pectoralis major tendon was transferred to the lesser tuberosity. This technique was alerted by Resch et al., in which the pectoralis major is transferred deep to the conjoint tendon. Their theory was that this would provide a direction of force that is more comparable to the native subscapularis pull.[22] Specifically, the maximum abduction angle, external rotation angle, and humeral translations at maximal abduction better mimic a native glenohumeral joint.[18] An extended deltopectoral approach is often used in the procedure. The cephalic vein and conjoined tendon complex are identified first, after which the deltoid is retracted laterally. Attention is then given to the conjoined tendon, at which time the entire tendon is dissected and separated from the pectoralis minor by blunt dissection. At this point, the musculocutaneous nerve should be identified. Following this, the pectoralis major tendon insertion onto the bicipital groove should be identified. The superior two-thirds of the tendon should be detached from the humerus, and the muscle fibers of the detached section are split with blunt dissection. Specifically, the clavicular portion of the tendon should be isolated for transfer. It is then passed laterally posterior to the conjoined tendon, but anterior to the musculocutaneous nerve, identified earlier. The pectoralis tendon is rerouted beneath the conjoined tendon, which lies under the coracoid process. The tendon is then attached to the lesser tuberosity and anterior portion of the greater tuberosity with suture anchors.[18]

In their study, Resch et al. saw an improvement in the mean Constant score from 22.6 points preoperatively to 54.4 points postoperatively. Included in this was improvement in pain with the majority of patients. A 2010 study by Gavriilidis et al. found a Constant score increase from 51.73 ± 16.18 to 68.17 ± 8.84 points postoperatively. Within the subcategories, they saw significant improvement in pain and activities of daily living, as well as an insignificant increase in range of motion and strength.[18] Some studies have shown a decrease in range of motion following this procedure.[17] However, the study by Gavriilidis et al. did not observe this. This was attributed to only transferring the superior two-thirds of the tendon, as opposed to the entire muscle in other studies.[18] Strength improvement following the procedure has mixed results, with Gavriilidis et al. finding no significant increase, but a study conducted by Jost et al. demonstrating significant improvement between preoperative and postoperative strength in abduction.[18,23] The most common adverse effect of this procedure is injury to the musculocutaneous nerve, though it is frequently only a transient palsy.[23] Overall, chronic subscapularis tears are a source of pain and disability that may not be amenable to traditional surgical repair methods. Subcoracoid transfer of the pectoralis major tendon provides benefits in shoulder function and pain in these patients.

6. PECTORALIS SURGERY IN SCAPULAR WINGING

Scapular winging is a rare phenomenon that can present with protrusion of the scapula along with shoulder/ upper back pain, stiffness, decreased range of motion, and weakness that are worsened with overhead activities. Depending on the severity of symptoms and the patient's occupation and activity level, scapular winging could have a significant effect on a patient's life.[24]

Treatment of this condition depends on its etiology, of which there are many. The most common causes of scapular winging involve damage to the serratus anterior, trapezius, or rhomboid muscles and/or associated nerves. Injuries to these structures can be traumatic, sports-related, iatrogenic, or spontaneous. Damage to the serratus anterior muscles or long thoracic nerve that supplies them results in medial scapular winging where the scapula is shifted medially and superiorly. Damage to the trapezius or spinal accessory nerve results in lateral scapular winging where the superior angle of the scapula is laterally shifted. Lastly, damage to the rhomboids or dorsal scapular nerve led to a laterally shifted inferior scapular angle. This section of our review will further investigate serratus anterior-related lesions, as these account for the majority of scapular winging cases and is the only major etiology where pectoralis surgery has indication in treatment that is associated with good outcomes.[25]

6.1. SERRATUS ANTERIOR

To understand the biomechanics of serratus anterior palsy symptoms and predisposing injury, it is important to briefly review the relevant anatomy. The muscle originates from ribs 1-9, coarse posteriorly along the thoracic cage, and insert along the superior angle, medial border, and inferior angle of the scapula. This anatomy allows for protraction and rotation.[25] The long thoracic nerve innervates the serratus anterior and arises from nerve roots C5-7. It first travels inferiorly going anterior to the posterior and middle scalenes and then continues distal-laterally, beneath the clavicle but superficial to ribs 1 & 2, along the chest wall at the mid-axillary line for ~22-24 cm.[25,26] This long course leaves the long thoracic nerve particularly susceptible to injury especially by compression from the scalene muscles.

Serratus anterior palsy is most amenable to conservative treatment, with only 25% of conservative treatments failing.[25] Following blunt trauma or stretching injury (i.e. sports injuries), an electromyography (EMG) should be obtained after 6 weeks. After confirmation of long thoracic nerve injury, conservative treatment should be initiated depending on which of the three stages of healing the long thoracic nerve is in.[24]

In cases where conservative treatment fails, surgery can be considered to correct scapular winging due to serratus anterior palsy. One review identified initial nerve exploration surgery with neurolysis or nerve transfer followed by dynamic muscle transfer for failed initial procedures as the sequence of surgical treatments that led to the best outcomes.[25]

In the neurolysis procedure, a 6-8 cm incision is made parallel to the clavicle ~2 finger widths posterior to it. The platysma is dissected out and then the omohyoid is retracted to reveal the scalene fat pad. The fat pad is then elevated to expose the brachial plexus. Using microsurgical

techniques, internal and external neurolysis is performed by resecting the superficial 20% of the anterior scalene. The middle scalene is also dissected along with compressing fascial bands, which decompresses the long thoracic nerve. During the procedure, it is important to be wary of injury to the supraclavicular nerves.[27] Nerve transfer surgery to the long thoracic nerve is accomplished by retracting the latissimus dorsi in the posterior axillary region, which exposes the long thoracic and thoracodorsal nerves. Long thoracic nerve palsy is confirmed by intraoperative nerve stimulation. Then, the branch of the thoracodorsal nerve that showed stronger muscle contraction with stimulation is used as the donor nerve. The long thoracic nerve is then divided proximally, and a nerve suture without tension or nerve graft is used to transfer the donor thoracodorsal nerve. Almost all patients had satisfactory improvement in symptoms in the studies that assessed outcomes of the above two procedures, although sample size was small.[27]

The other surgical option is a muscle transfer procedure using the sternal head of the pectoralis major.[25] In this procedure, an axillary incision is made that courses posteriorly along the axillary floor to expose both the pectoralis major insertion and inferior scapula. Caution should be exercised to avoid damage to the subscapular nerve. Enough tendon is then dissected from the sternal part's humeral insertion so that it can be anchored to the ensuing fascial tube. The supra- and infraspinatus muscles are then retracted so that a 6 mm hole can be drilled ~2.5 cm superior to the inferior scapular angle and ~1.3 cm medial to the lateral scapular border. The fascial tube containing the donor tendon is then passed through this hole and attached. After the procedure, the shoulder must be immobilized in a 15 degree abduction pillow for 3 weeks followed by 6 weeks of restricted passive ROM exercises with maximal flexion and internal rotation of 30 and 80 degrees respectively.[27]

Another technique involving the pectoralis major is called the split pectoralis major transfer surgery. The sternal head of the pectoralis major is transferred from its insertion site on the humerus to the inferomedial aspect of the scapula in cases of scapular winging caused by serratus anterior palsy.[27] With the patient in a left lateral decubitus position and the arm abducted, two incisions are made: one over the axillary skin crease and a second over the inferior angle of the scapula. The sternal head of the pectoralis major is dissected away from its insertion on the humerus medially to avoid any neurological or vascular structures, and the free tendon is passed through the second incision. Once the surgeon determines that the scapula has been reoriented into a proper anatomical position, sutures are passed through the free pectoralis major tendon and anchored into the scapula via drill holes.[27]

These surgical techniques that employ the pectoralis major muscle as a transfer tendon to fix scapular winging have demonstrated variable efficacy in patients undergoing primary transfer, while patients with split tendon transfer typically fully regain motion.[27]

7. SUMMARY

Understanding the anatomy of the pectoralis muscle is critical in diagnosis and management of various conditions affecting the upper body. The pectoralis major serves an important role in adduction, flexion, and internal rotation of the upper extremity, allowing individuals to bear weight and pull the arm across the body. Its two heads, originating from the clavicle and sternum, twist and join to insert lateral to the intertubercular groove of the proximal humerus. The strength, size, and proximity of the pectoralis major muscle to other muscles around the glenohumeral joint make it a favorable candidate in certain salvage procedures of the upper extremity. Primary pectoralis major tears are typically treated surgically due to improved outcomes in functionality, pain scores, and patient satisfaction. Transfers of the pectoralis major are used in younger patients with isolated scapular winging and subscapularis tears as a salvage procedure due to the ability to rebalance muscular forces around the glenohumeral joint that may be lost in these pathologies. The role the pectoralis major muscle plays within a surgical landscape can include more than just primary ruptures of the muscle, and a thorough understanding of its complex anatomy and surrounding structures is essential when performing surgeries, whether it be primary rupture repairs or tendon transfers.

ABBREVIATIONS

MRI-Magnetic Resonance Imaging
TOS-Transosseous suture
ROM-Range of motion
EMG-electromyography

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AL and NE were involved in manuscript drafting and conception. All authors were involved in manuscript preparation, literature search, manuscript writing, and made significant contributions in the final editing and approval process. All authors have read and approved of the final manuscript. EL was responsible for manuscript submission.

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