

Glenohumeral Translations in Overhead Workers with Subacromial Impingement Syndrome - A Review

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ABSTRACT

Introduction: The third most common musculoskeletal condition is shoulder pain with a prevalence of up to 70%. The second most frequent shoulder condition is subacromial impingement syndrome. Impingement can be classified as either anterosuperior or posterosuperior. Faulty posture, altered scapular or glenohumeral kinematics, posterior capsular tightness, and acromial or coracoacromial arch pathology are all potential extrinsic mechanics that can lead to Subacromial impingement syndrome. The purpose of this review is to find the different variation in translation that takes place in the glenohumeral joint in Subacromial impingement syndrome in overhead workers.

Methods: We reviewed the various translations observed in the glenohumeral joint in subacromial impingement syndrome and discussed the evidence-based studies. For the review, an electronic search for relevant articles using PUBMED, Pedro, Research Gate, and Google Scholar databases up to Dec 2022 was done wherein MeSH search terms and free words were used. Articles underwent the selection process and were selected based on inclusion criteria. Articles were selected based on the author's expertise, self-knowledge and reflective practice.

Results: The current study included 11 articles that fulfilled the inclusion criteria suggesting that various humeral translations in overhead workers. The above-reviewed studies provided evidence that based on occupational demands abnormal variations occur.

Conclusion: This review has provided an overview of the previous and recent literature on humeral head translation seen in sub-acromial impingement. This study concludes that superior translation is more common as compared to anterior-superior translation and posterior-superior translation.

Keywords: Anterior, Posterior, Superior Translation, Subacromial impingement

Introduction

The third most common musculoskeletal condition is shoulder pain. Shoulder discomfort is estimated to affect 14.7 people, with a prevalence of up to 70%. In society, up to 20% of the adult population has shoulder symptoms which are pain, and restricted motion at any given moment, which appears to be growing. The second most

frequent shoulder condition is sub-acromial impingement syndrome (SAIS), which accounts for roughly 13.8 percent of all shoulder discomfort complaints.¹ Neer in 1983, defined impingement as a mechanical compression injury of the tissues of the subacromial region. The subacromial region is defined superiorly by the coracoacromial arch,

inferiorly by the humeral head, and laterally by the anterior half of the acromion. Between these two osseous structures lie the structures that are impinged.² The SAIS has a complex etiology that can be classified as intrinsic or extrinsic, and will then emerge as weakening, muscle imbalances, osteophytes, acromial changes, and altered kinematics leading to impingement. The intrinsic impingement develops from a degenerative process brought on by repeated usage, tension overload, or trauma to the tendons. Extrinsic impingement, in which the tendon becomes inflamed and degenerates as a result of coracoacromial arch pathology, improper posture, changed scapular or glenohumeral kinematics, and capsular tightness.³ Intrinsic impingement is a frequent cause of shoulder pain among overhead industrial workers. The rotator cuff muscle gets impinged between the greater tuberosity of the humeral head and the posterior-superior portion of the glenoid border when the arm is subjected to extreme ranges of abduction and external rotation. There are two types of internal impingement: antero-superior and posterior-superior.⁴⁻¹¹ The greater tuberosity and

the coracoacromial arch may intrude on the rotator cuff (subscapularis, supraspinatus, infraspinatus, and teres minor tendons) and other subacromial tissues, leading to impingement.^{12,13} Six degrees of freedom, three rotations, and three translations are available in the glenohumeral joint. As the study advances, new information regarding the translation of the humerus is being documented. Several researchers evaluated translations during particular phases of elevation while performing overhead activity. Theoretically, an increase in the normal superior and anterior humeral head translation would result in mechanical compression of the tissues in the subacromial area during glenohumeral motion. Along with scapular, thoracic biomechanics are altered.^{14,15} Magnetic resonance imaging, ultrasonography, and radiography were used to investigate the acromion-humeral distance (AHD), a linear measure between the acromion and the humeral head used to quantify the subacromial space in individuals with Rotator cuff illness. In healthy shoulders, AHD is usually between 7 and 14 mm which is reduced to less than 7 mm in SAIS patients.^{15,16}

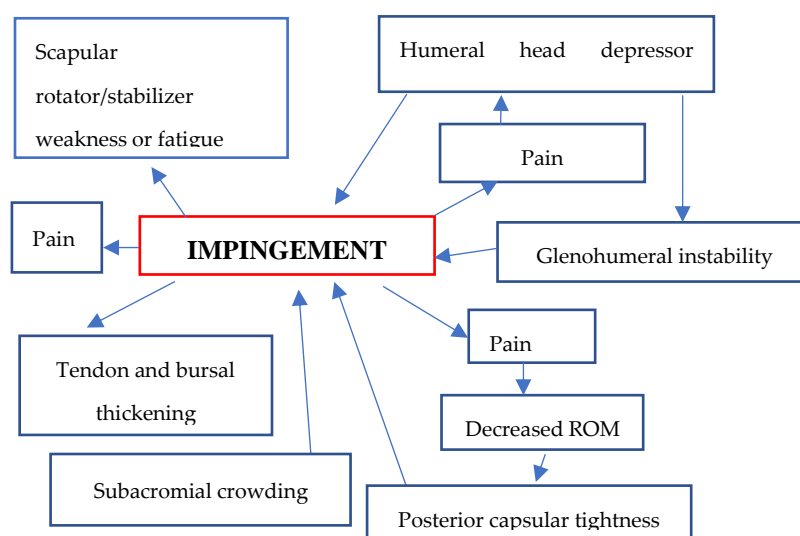


Fig 1: Diagrammatic representation of the mechanism of injury of shoulder impingement

For physical functioning, the upper extremity is a crucial component of our body. The upper extremity is used for several daily tasks, including picking up objects, transferring objects, combing, bathing, and many other tasks.¹⁷ Employees in the

construction industry perform a variety of tasks. To accomplish this work, individuals repeatedly lift and carry objects overhead. To work efficiently complete shoulder range of motion and strength of the rotator cuff muscles are important

components.¹⁸ Work duties that repeatedly put a strain on the shoulder joint and involve holding objects over the head higher cause harm. Thus, causing tendinitis, degeneration and rupture of the supraspinatus tendon. Shoulder issues like repetitive overhead activity, digging activity, heavy lifting, and shoulder trauma have also been linked to repetitive employment exposure.¹⁹ Also, Physical therapists should be educated on the treatment approaches and prevention of these injuries since they are experts in work analysis, biomechanics, and pain management. Homemaking chores and leisure activities should be included with work-related activities because they contribute to stressful conditions.²⁰

Methods

Search Strategy:

A review was performed to study the variations in the translation of the glenohumeral joint in subacromial impingement syndrome. For this review, an electronic search for relevant articles was done using Google Scholar, PUBMED, MEDLINE, Pedro, Research Gate and CINHAL databases up to December 2022 was done where in MeSH search terms such “Subacromial impingement”, “glenohumeral kinematics”, “glenohumeral translation”, “joint positional fault” recent advances and free words were used. Boolean operators like “AND”, “OR” and “AND NOT” were used. In addition to the electronic search, articles were searched manually for relevant studies. Articles were selected based on the authors' expertise, self-knowledge and reflective practice.

Study Selection:

A review was undertaken. We included studies published in English up to December 2022, which focused only on the various glenohumeral translation that occurs in subacromial impingement syndrome. The study included only various translations observed on diagnostic tools. The selection criteria were reviewed according to each study.

Data Extraction:

All steps in the selection and extraction processes were assessed. The titles and abstracts of the

references were screened. Full texts of relevant publications were reviewed and were included if they met the inclusion criteria. One researcher collected the database and included the relevant ones based on the inclusion criteria. The inclusion criteria for the study were:

1. Patient with subacromial impingement syndrome
2. Translation seen on the diagnostic tool (Xray, MRI, Ultrasound)
3. Various translations (superior, superior anterior, superior posterior, inferior)

Then these databases were studied by researcher 2 and were analysed and discussed. Then both researchers read and reviewed the final data to avoid any bias.

Results

The current study included 11 articles that fulfilled the inclusion criteria focusing on the translations that are seen in SAIS. According to Heiko Graichen et al., a study on the developed MR-based technique that makes it possible to evaluate humeral head translation three-dimensionally in functionally important arm positions with and without muscle activity wherein the result showed that the translation of the humeral head increases up to 1-3 mm in the superior direction occurs in the first 30-60° of active glenohumeral elevation in scaption. Along with that, there was inferior translation observed from 30 to 150 was only 1.2 mm. In another study, the shoulders of 12 healthy people were examined using an open MRI system at 30, 60, 90, 120, and 150 degrees of arm elevation. The adductors and abductors were contracted isometrically twice as a result of a 15-newton Force being applied to the distal humerus. The scapulo-humeral rhythm (2.2–2.5) and scapular tilting (2–4) and glenohumeral translation were calculated from the MR image data for both abducting and adducting muscle activity, and the results showed that no significant difference between the two types of muscle activity during elevation. Between 30 and 120 of arm elevation, a substantial superior translation of 0.6–1.8 mm was seen during abducting muscle action compared to adducting

muscle activity. The humeral head was just 1.00 mm superior to the glenoid center at 60 degrees of abduction. The humeral head was posterior to the glenoid center (1.3–2.3 mm) in the anterior–posterior direction at all elevation angles during abducting muscle action.^{22,23}

A study by Lori A. Michener et al. on anatomical and biomechanical mechanisms of subacromial impingement syndrome stated that there were increased anterior and superior humeral head translations and decreased posterior tipping, external rotation and upward rotation. Also, the evidence indicates that glenohumeral and scapular kinematics are altered; subacromial impingement is the most common cause of shoulder pain, causing or resulting from multiple factors. Besides this a study by Paula M. Ludewig, *Translations of the humerus in Persons with Shoulder Impingement Symptoms: studied Persons with symptoms of shoulder impingement* showed small but significant changes in anterior-posterior translations of the humerus, consistent with possible reductions in the available subacromial space, according to three-

dimensional humeral translations in symptomatic construction workers and an asymptomatic comparison group while elevation of the arm in scaption with different weights of 2.5 and 4.5 kgs in 3 phases of motion. On the other hand, Nadja Saupe et al. conducted a study on the association between rotator cuff abnormalities and reduced acromiohumeral distance. They found that in group 1 (acromiohumeral distance 7 mm), full-thickness supraspinatus tendon tears were present in 90% of the patients, infraspinatus tendon tears were present in 67 percent and subscapularis tendon tears in 43% of the patients.^{24,25,26}

A study by Medhat M. Refaat et al. comparing the efficacy of shoulder ultrasound and magnetic resonance imaging in shoulder impingement on 31 subjects stated that ultrasound is comparable to MRI, however, it is more accurate in full-thickness tears. Because ultrasound is less expensive and more widely available, and because it offers dynamic real-time assessment, it could be employed as a first-line examination in patients with shoulder pain.²⁷

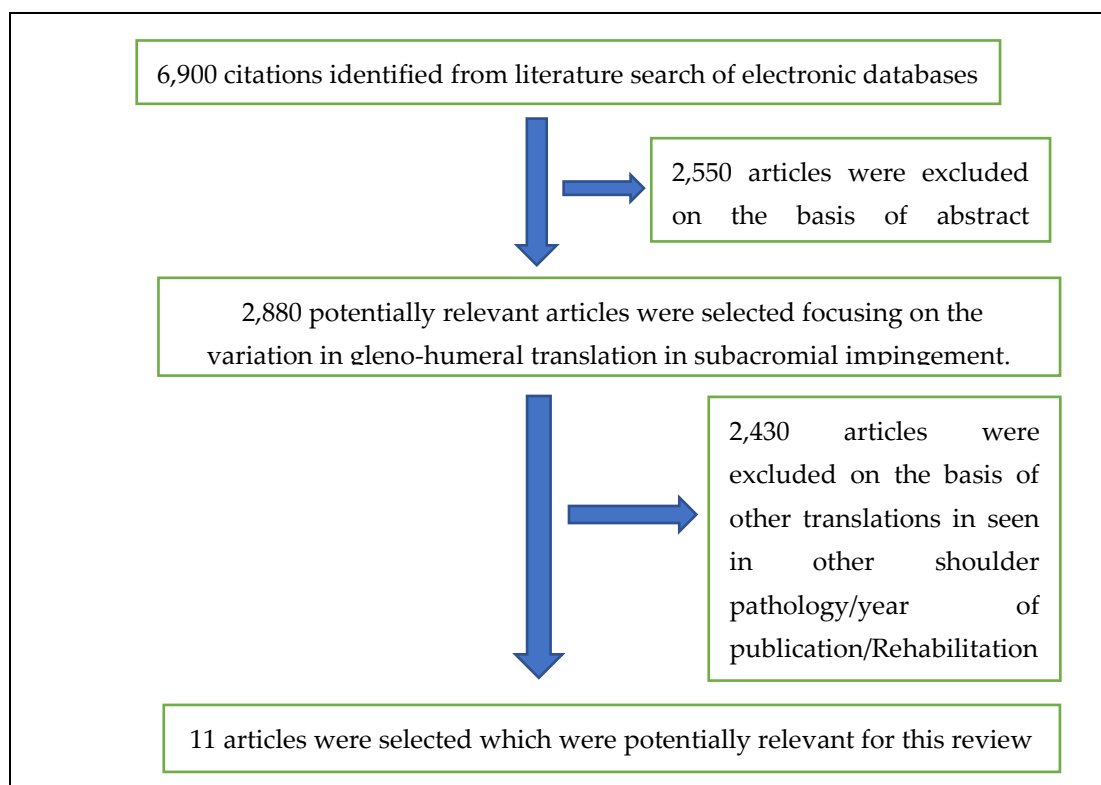


Fig 2: Flowchart depicting selection of database for the review

Table 1: Summary of the evidence-based literature on glenohumeral translation in sub-acromial impingement.

TITLE AND NAME OF AUTHOR	OUTCOME VARIABLE	REMARKS
1. Glenohumeral translation during active and passive elevation of the shoulder a 3D open-MRI study Heiko Graichen et al. ²²	They investigated based on MR that allowed them to explore the three-dimensional translation of the humeral head in functionally significant arm postures both with and without muscular action.	The first 30 to 60 degrees of active glenohumeral scapular plane elevation results in a 1-3 mm translation of the humeral head in the superior direction. Additionally, there was subpar translation from 30 to 150 which was only 1.2 mm.
2. Effect of abducting and adducting muscle activity on glenohumeral translation, scapular kinematics and subacromial space width in vivo H. Graichen et al. ²³	With an open MRI system, the shoulders of 12 healthy subjects were examined at 30, 60, 90, 120, and 150 degrees of arm elevation. The adductors and abductors were isometrically contracted twice as a result of a 15 N strain being applied to the distal humerus. Both the abducting and adducting muscle activity's scapulohumeral rhythm, scapular tilting, and glenohumeral translation were estimated from the MR imaging data.	No significant change was identified in the muscle activity of the abducting and adducting muscles during elevation, and the scapulo-humeral rhythm (2.2-2.5) and scapular tilting (2-4) remained largely consistent. Between 30 and 120 of arm elevation, a substantial superior translation of 0.6–1.8 mm was seen during abducting muscle action compared to adducting muscle activity. The humeral head was just 1.00 mm superior to the glenoid center at 60 degrees of abduction. The humeral head was posterior to the glenoid center (1.3–2.3 mm) in the anterior–posterior direction at all elevation angles during abducting muscle action.
3. Anatomical and biomechanical mechanisms of subacromial impingement syndrome Lori A. Michener et al. ²⁴	According to the data, the glenohumeral and scapular kinematics are altered; SIS is the most prevalent cause of shoulder pain and can be brought on by a variety of causes or consequences.	Superior and anterior humeral head translations were increased, but posterior tipping, external rotation, and upward rotation were decreased.
4. Translations of the Humerus in Persons with Shoulder Impingement Symptoms Paula M. Ludewig et al. ²⁵	Three-dimensional humeral translations were tracked in symptomatic construction workers and an asymptomatic comparison group while elevating the arm in the scapular plane under no-load, 2.3-kg, and 4.6-kg hand-load conditions. Between-group comparisons were made across 3 phases of motion (30°–60°, 60°–90°, and 90°–120°) and the association between humeral translations and cross-body adduction and	People with shoulder impingement symptoms had minor but noticeable alterations in the humerus' anterior-posterior translation, which is consistent with a potential reduction in the amount of accessible subacromial space.

TITLE AND NAME OF AUTHOR	OUTCOME VARIABLE	REMARKS
	shoulder internal rotation ROM measure.	
5. Association Between Rotator Cuff Abnormalities and Reduced Acromio-humeral Distance Nadja Saupe et al. ²⁶	Acromiohumeral distance was measured on plain radiographs and on MR images	Full-thickness supraspinatus tendon tears were evident in 90% (19/21) of the patients in group 1 (acromiohumeral distance 7 mm), infraspinatus tendon tears were present in 67% (14/21) of the patients, and subscapularis tendon tears were present in 43% (9/21) of the patients.
6. Comparing Efficacy of Shoulder Ultrasound and Magnetic Resonance Imaging in Shoulder Impingement Medhat M. Refaat et al. ²⁷	Thirty patients with a clinical diagnosis of subacromial impingement were scanned by US and MRI. The results of the two modalities were compared and documented.	While ultrasonography is comparable to MRI in the assessment of shoulder impingement syndrome and rotator cuff tears, it is more accurate in full-thickness tears. US could be used as a first-line examination in patients with shoulder pain since it is more accessible, less expensive, and allows dynamic real-time assessment.
7. Ultrasound measurement of rotator cuff thickness and acromiohumeral distance in the diagnosis of subacromial impingement syndrome of the shoulder Jerzy J. Cholewinski et al. ²⁸	In 57 patients with unilateral symptoms of impingement syndrome, both shoulder joints were examined using ultrasound technology. This included measuring the thickness of the rotator cuff and the distance between the inferolateral edge of the acromion and the apex of the greater tuberosity of the humerus (AGT distance) in the standard positions for ultrasonography.	It was possible to diagnose subacromial impingement syndrome of the shoulder using an ultrasonographic examination of humeral head elevation as determined by the AGT distance. AGT distances of more than 2.1 mm and rotator cuff thickness differences of more than 1.1 mm may indicate rotator cuff muscle dysfunction between the two shoulder joints.
8. Shoulder muscle imbalance and subacromial impingement syndrome in overhead activity individuals. Phil Page. ²⁹	-----	A change in shoulder kinematics may also be caused by imbalances in the glenohumeral rotation range of motion. To be more precise, excessive external rotation causes the humerus' anterior and inferior translation to rise, which causes anterior instability.
9. The acromion-greater tuberosity impingement index: A new radiographic measurement and its association with rotator cuff pathology	In 83 patients, the ATI was assessed using magnetic resonance imaging (MRI) and X-ray analyses.	The ATI is a good indicator of degenerative rotator cuff disease on both X-ray and MRI, as shown by the ROC curves. The ATI is also a reliable indicator of subacromial impingement syndrome and

TITLE AND NAME OF AUTHOR	OUTCOME VARIABLE	REMARKS
Hai-Xiao Liu et al. ³⁰		degenerative supraspinatus tendon tears.
10. The Combined Dynamic and Static Contributions to Subacromial Impingement A Biomechanical Analysis Loel Z. Payne et al. ³¹	A dynamic shoulder model replicating rotator cuff, deltoid, and biceps muscular stresses was used to assess ten human cadaveric shoulders. Using minimally invasive, very small pressure transducers, the combined impact of the muscle forces and acromial structure on subacromial impingement was assessed.	A frequently used muscle force per cross-sectional area has been determined by several authors to forecast the total force-generating potential of muscle. The study sought to avoid the numerous variances provided by this muscle configuration. In previous biomechanical impingement investigations, values between 32 and 40 N/cm ² were employed, and the muscle forces are very similar to those values. To raise the arm from the shoulder, the deltoid muscle exerts an average force of 270 N.
11. Shoulder impingement syndrome in relation to shoulder-intensive work Poul Frost, Johan Hviid Andersen. ¹⁹	Diagnostic test, signs of Impingement	Shoulder ROM above 30degree was impaired.

Discussion

This review aimed to summarize and identify the current literature on variations in the translation of the glenohumeral in subacromial impingement. Though magnetic resonance imaging is the gold standard investigation there are other investigations also which help us to know the translations. According to the need following articles are mentioned above in Table 1. with available data on the research website. Although there is a lack of data availability about the translation occurring in the humerus in subacromial impingement. There are a few studies according to the test and the new revised investigation method that are discussed further. A study by Hai-Xiao Liu et al. on the acromion-greater tuberosity impingement index: A new radiographic measurement and its association with rotator cuff pathology on 83 individuals with rotator cuff pathology and acute rotator cuff tear concluded that according to the rotator cuff curves, the Acromion tuberosity index is a good predictor of degenerative rotator cuff pathology on both X-ray and MRI. Also, the ATI is a good predictor of

degenerative supraspinatus tendon tears or subacromial impingement syndrome.³⁰

Muscle imbalance may also be the cause for the impingement a study by Phil Page on shoulder muscle imbalance and subacromial impingement syndrome in overhead activity individuals summarizes the imbalances in glenohumeral rotation range of motion may also contribute to altered shoulder kinematics.²⁸ Specifically, excessive external rotation leads to increased anterior and inferior translation of the humerus, leading to anterior instability. Also, Jerzy J. Cholewinski et al. studied ultrasound measurement of rotator cuff thickness and acromio-humeral distance in the diagnosis of subacromial impingement syndrome of the shoulder in 57 individuals with unilateral subacromial impingement symptoms stated that ultrasonographic assessment of humeral head elevation, measured as the acromial greater tubercle distance, proved to be useful in establishing the diagnosis of the subacromial impingement syndrome of the shoulder. A difference in rotator cuff thickness of more than

1.1 mm and a difference in the AGT distance of more than 2.1 mm between both shoulder joints may reflect dysfunction of rotator cuff muscles.²⁹

Another way to study the amount of tension generated by the muscles to cause subacromial impingement is a study by Loel Z. Payne et al. that Combined Dynamic and Static Contributions to Subacromial Impingement. A biomechanical analysis on 10 human cadaveric shoulders was tested with a dynamic shoulder model simulating physiologic rotator cuff, deltoid, and biceps muscle forces. The combined effect of the muscle forces and acromial structure on subacromial impingement was measured with minimally invasive, miniature pressure transducers. The result stated that the multiple variations posed by this muscle arrangement, a commonly used muscle force per cross-sectional area has been estimated by numerous authors to predict the total force-generating potential of muscle. The

muscle forces closely approximate the values of 32 to 40 N/cm² used in other biomechanical impingement studies. The average deltoid muscle force of 270 N to elevate the arm in from the shoulder.²⁶

A study by Poul Frost, and Johan Hviid Andersen on Shoulder impingement syndrome in relation to shoulder intensive work. The result stated that the shoulder symptoms and impingement syndrome are greater among current and former slaughterhouse workers than among referents and the analyses of shoulder function showed a decrease in all functional measures among participants with long-lasting symptoms and even more among participants with a clinical diagnosis.³¹ Table 2 below summarizes the studies based on evidence-based literature on the preferable approach for the surgery and muscles impinged.

Table.2: Studies summarised on the basis of evidence-based literature on preferable approach for the surgery and muscles impinged.

Article Name	Author Name	Superior Translation (supraspinatus)	Anterior-Superior Translation (subscapularis)	Posterior-Superior Translation (infraspinatus)
1. Combined Sub-coracoid and Subacromial Impingement in Association with Anterosuperior Rotator Cuff Tears: An Arthroscopic Approach. ³²	Peter M. Parten and Stephen S. Burkhart	19%	19%	-
2. Association Between Rotator Cuff Tears and Superior Migration of the Humeral Head An MRI-Based Anatomic Study. ³³	Matthew Y. Siow et al.	67.7%	31.1%	46.3%
3. Comparison of 3-Dimensional Scapular position and Orientation Between -subjects With and Without Shoulder Impingement. ³⁴	Amy Cole Lukasiewicz.	45%	-	-

A study that compared the scapular position and orientation between subjects with and without impingement syndrome was done on 37 including individuals with impingement and normal individuals. A 3-dimensional electromechanical digitizer was used to measure scapular position and orientation in 3 planes of elevation i.e. arm at the side and elevated in the scapular plane to horizontal, also at maximum elevation. The result stated in both impingement and nonimpaired groups, the scapula displayed a typical pattern of rising posterior-tilt angle, increasing upward-rotation angle, and decreasing internal-rotation angle during the scapular plane elevation of the arm. With increased arm elevation, the scapula also migrated to a more superior and slightly more medial position. Those with impingement had a considerably lower posterior tilting angle of the scapula in the sagittal plane than non-impaired participants (34.6° ± 9.7) (25.1° ± 9.1). When compared to non-impaired subjects, impingement patients had a higher superior-inferior scapular position with maximal arm elevation (5.2 cm to 1.6 below the first thoracic vertebrae) (7.5 cm to 1.5).³⁴

A study by Matthew Y. Siow et al. on the association between rotator cuff tears and superior migration of the humeral head and MRI-based anatomic study. A total of 257 patients were included in the study. Full-thickness tears of the supraspinatus, infraspinatus, or subscapularis tendon were associated with significantly decreased AHI. Although several forms of RCTs have been linked to superior humeral head migration, this study found a link between a complete RCT and superior humeral head migration. Tears of the infraspinatus tendon proved to have the most impact on keeping the humeral head in its natural position. More research is needed to see if repairing these tears early can help decrease the progression of rotator cuff illness.³³

Peter M. Parten and Stephen S. Burkhart conducted a study on combined sub-coracoid and subacromial impingement in association with anterosuperior rotator cuff tears: An Arthroscopic Approach. Eight patients were taken. All of the

patients had rotator cuff injuries with all the muscles injured subscapularis, supraspinatus, and infraspinatus. Arthroscopic subacromial decompression, sub-coracoid decompression, and rotator-cuff repair were performed on all of the patients. Results stated that two patients had outstanding results after surgery, five patients had good results, and one patient had a medium result. Postoperatively, all patients experienced a considerable reduction in pain, with four patients reporting total pain removal throughout all activities. There were no complaints of anterior coracoid discomfort or positive impingement symptoms after surgery. Active forward elevation rose from 103.1° ± 46.5° preoperatively to 155° ± 18.5° postoperatively (P .02). Four patients had no active overhead function and positive Napoleon tests before surgery. Following surgery, all patients improved their Napoleon test scores and restored active overhead function.³² Thus, in the over-head worker population, arthroscopic treatment like decompression surgery, and repair surgery of sub-coracoid and subacromial impingement can produce positive effects. In order to provide pain relief and increased function, a high index of suspicion for these coupled lesions.

Physical therapy methods that include a patient-centered approach, home exercises, and postural correction are the prime aspects of managing at an early stage to avoid the later consequences.³⁵ Also, physiotherapy management focuses on both functional and vocational rehabilitation. All the effects enhanced the patient's overall functions of the shoulder, elbow, and wrist, to resume work early.³⁶ A pre-planned exercise regime and ergonomics like correcting the posture by shoulder shrug, and shoulder retraction exercises be advised that can be incorporated into these individuals and their effects and changes on the translations can be studied. Also, this review has been done in general regarding overhead workers so, occupation-specific research can also be carried out further.

Conclusion

This review has provided an overview of the previous and recent literature on humeral head

translation seen in sub-acromial impingement in overhead workers. As we know the etiology of sub-acromial impingement is complex. The sub-acromial impingement has multifactorial causes. The above-reviewed studies provided evidence that based on occupational demands abnormal variations occur. Similarly, the level of physical activity and ergonomics also contribute to the variations. This study concludes that superior translation is more common as compared to the other translations. These shoulder disorders can occur due to a variety of underlying conditions

and hence likely include disorders with different prognoses, which might be one of the variables that may have an impact on risk estimations. Also, the cumulative exposure to work and the average length of the illness will probably lengthen and thus the absenteeism.

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