CHARLES UNIVERSITY

FACULTY OF PHYSICAL EDUCATION AND SPORT

DEPARTMENT OF PHYSIOTHERAPY

Comparison Between the Effectiveness of Extracorporeal Shockwave Therapy (ESWT) and the Surgical Approach in the Treatment of the Rotator Cuff Tendinopathy: A Literature Review

Master Thesis

Supervisor:
Doc. Paed Dr. Dagmar Pavlů, CSc

Author:
Mohammed Saqqa

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Declaration

I hereby declare that all the work that is presented on this Master Thesis is done by me, and I have proclaimed all the information and the literature sources which I used in this thesis work (in the bibliography section). Also I further declare that none of this thesis or any part of it have been used for the attainment of same or any other academic degree.

Mohammed Saqqa

Acknowledgment

I would like to express my sincere gratitude to the supervisor of my thesis Doc. Paed Dr. Dagmar Pavlů, CSc for her great support and her continues guidance that kept me motivated and helped me to complete the writing of this master thesis.

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Dedications

I dedicate this master thesis to my mother, my wife, my brothers and sister who have been giving me strength, hope, and inspiration throughout this hole journey with their true love, continues prayers, and big hearts that embraced me and encouraged to finish this study.

Abstrakt

Název

Porovnání účinnosti léčby tendinopatie rotátorové manžety mimotělní rázovou vlnou (ESWT) a chirurgickým zákrokem.

Cíl

Hlavním cílem této výzkumné práce bylo porovnat účinnost léčby tendinopatie kalcifikované rotátorové manžety buď mimotělní rázovou vlnou (ESWT) nebo chirurgickým. (artroskopickým) zákrokem, a to pomocí ukazatelů Constant-Murleyho skóre (CMS) a vizuální analogové škály (VAS) uváděných v odborné literatuře z posledních let.

Metodika

Diplomová práce spočívá v systémové literární rešerši. Zařazeny do rešerše byly randomizované kontrolované klinické studie, prospektivní studie a retrospektivní kazuistiky psané v anglickém jazyce a publikované v rozmezí let 2000 – 2018. Publikace byly vyhledávány v těchto databázích: EMBASE, PubMed, CINAHL, Medline, SpringerLink, ProQuest, a to za použití různých kombinací klíčových slov. Do studií byli zařazeni muži i ženy, a to každého věku. Zkoumanou patologií byla tendinopatie kalcifikované rotátorové manžety. Pokud jde o typy metod, byla použita radiální i fokusovaná ESWT nízké, střední i vysoké intenzity; intervence byly vesměs artroskopické.

Výsledky

Po konečném hodnocení studií se jich pro zařazení do tohoto výzkumu kvalifikovalo pouze 33, z toho 21 z oblasti rázových vln a 12 z chirurgické oblasti. Všechny byly publikovány v rozmezí let 2000 – 2016. Věk pacientu se pohyboval v rozmezí od 26 do 83 let. Články zabývající se léčbou rázovou vlnou zahrnovaly FESWT i RESWT při různých energetických úrovních (nízká, střední, vysoká), chirurgicky orientované články pojednávaly o artroskopickém débridementu (odstraňování) kalcifikace rotátorové manžety a/nebo o akromioplastice. Vlivem ESWT i artroskopie došlo jak u skóre CMS, tak u skóre VAS k posunu, větší zlepšení bylo ovšem zjištěno ve studiích ESWT.

Závěr

Jsou sice důkazy na podporu účinnosti artroskopické intervence při léčbě chronické tendinopatie kalcifikované rotátorové manžety a dalších patologií šlach, ovšem jejich zdroje nejsou zcela spolehlivé. Lze tedy uzavřít, že pacientům s tendinopatií rotátorové manžety lze doporučit, aby jako první volbu vybrali ESWT, která je v porovnání s chirurgickým výkonem považována za méně invazivní a snadno aplikovatelnou, a artroskopii vyhledali teprve potom, co léčba ESWT selže.

Klíčová slova

Tendinopatie rotátorové manžety, léčba mimotělní rázovou vlnou, artroskopie, kalcifikace ramene, tendinitida, chirurgický débridement, radiální rázové vlny, rotátorová manžeta, tendinóza, Constant-Murleyho skóre, léčba, terapie, vizuální analogová škála, fokusované rázové vlny.

Abstract

Title

Comparison between the effectiveness of extracorporeal shockwave therapy (ESWT) and the surgical approach in the treatment of the rotator cuff tendinopathy.

Objective

The main goal of this research work is comparing the effectiveness of extracorporeal shock wave therapy and the surgical intervention (arthroscopic approach) in the treatment of calcific rotator cuff tendinopathy depending on the outcome measures of the Constant-Murley Score (CMS), and the Visual Analogue Scale (VAS) from the recent scientific publications.

Methodology

This thesis is systemic (literature) review. The studies which recruited in this research were randomized controlled trials, prospective studies, and retrospective case series studies which written in English language form, and published between the year 2000 to the year 2018. The studies were retrieved from following databases: EMBASE, PubMed, CINAHL, Medline, SpringerLink, ProQuest using different integrations of the key words. The participants in the studies were from both genders and all ages. The type of the pathology which included in this research was chronic calcific rotator cuff tendinopathy. Regarding the intervention types both Radial, and Focused ESWT with low, medium, and high intensities and the arthroscopic interventions were the main types of interventions that are used in this study.

Results

After the final review of the studies only 33 studies were found qualified to be included in this research (21 shockwave articles, and 12 surgical articles). All of them were published between the year 2000 and the year 2016. With an approximated patients' ages that raged from 26 to 83 years of age. Both FESWT, RESWT in different energy levels (high, medium, low) in regarding the shockwave articles, and an arthroscopic debridement

(removal) of the calcification of the rotator cuff, and/or acromioplasty) in regarding the surgical articles. There was a significant difference in the CMS, and VAS after the application of both ESWT and the Arthroscopy but the more improvement was found in the ESWT studies.

Conclusion

There was evidence that supports the effectiveness of the surgical approach represented in the arthroscopic intervention in treating chronic calcific rotator cuff tendinopathy ant other tendon pathologies, but these evidence that found this effect are from the low level evidence. Thus, as a conclusion the patients with rotator cuff tendinopathy may advised to seek for the ESWT as their first option for treatment which is considered as a less invasive and easy to apply treatment method compared to the surgical approach, and seeks the arthroscopic approach in case of failure of the ESWT treatment.

Key words

Rotator cuff tendinopathy, Extracorporeal shockwave therapy, Arthroscopy, Shoulder calcification, tendinitis, surgical debridement, Radial shock waves, Rotator cuff, tendinosis, Constant-Murley score, therapy, visual analogue scale, focused shock waves.

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List of Abbreviations

AC: Acromioclavicular joint

ADL: Activities of daily living

CD: Calcific deposit

CMS: Constant-Murley Score

EDF: Energy flux density

ESWT: Extracorporeal shockwave therapy

FESWT: Focused extracorporeal shockwave therapy

G: Group count

Hz: Hertz

ISMST: International Society for Musculoskeletal Shockwave Therapy

MHz: Megahertz

MMT: Manual muscle test

MPa: Megapascal

MRI: Magnetic resonance imaging

NSAID: Nonsteroidal anti-inflammatory drug

OCD: Osteochondritis dissecans

PRP: Platelet-rich plasma

P-value: Probability value

RESWT: Radial extracorporeal shockwave therapy

ROM: Range of motion

SAD: Subacromial decompression

SC: Sternoclavicular joint

SECEC: European Society for Surgery of the Shoulder and Elbow

TENS: Transcutaneous electrical nerve stimulation

UPGL: Ultrasound-guided percutaneous lavage

US: Ultrasonography

VAS: Visual Analogue Scale

1. Introduction

Shoulder disorders affects a wide ratio of the world population; this may be a result of different diseases and disorders. However, the majority of the cases are related to rotator cuff tendinopathy. (Heron et al., 2017) Tendon pathologies are considered one of the most common sport injuries within the professional and the amateur athletes, and also among the non-athlete peoples, especially the people who works in jobs that requires a lot of manual skills. Tendon pathologies usually affects the tendons of the weight bearing muscles for e.g. Achilles, patellar, and some of the non-weight bearing muscles such as the rotator cuff muscles (especially supraspinatus muscle), and the tendon of the arm extensors due to many causes as in overloading these tendons in the work, or in the sport activities. (Dimitrios et al., 2014)

Rotator cuff tendinopathy is believed as one of the primary causes of shoulder pain in the sports and orthopedics medical clinics, especially in some jobs or sports activities which requires frequent repetitive overhead movements. (Leong et al., 2016) There are several methods being used to treat rotator cuff tendinopathy conditions such as the physical therapy modalities, exercises, etc. However, in this thesis research we will be focusing in comparing the effectiveness of the extracorporeal shockwave therapy and the surgical procedures in the treatment of the rotator cuff tendinopathy.

2. Background

2.1. Epidemiology and prevalence of the rotator cuff tendinopathy

Rotator cuff tendinopathy as mentioned previously is one of the most common musculoskeletal problems with a total prevalence rate of 16 percent, after the knee problems by 19 percent, and the lower back by 23 percent problems. (Longo et al., 2012) The prevalence of the asymptomatic calcific rotator cuff tendinopathy is ranged from 2.7 to 20 percent. (Louwerens et al., 2015) Rotator cuff tendinopathy is a condition that has a great effect on the patient's life making them to fall behind their jobs and minimize their productivity leading leaving them with several social and economical losses. (Vincent et al., 2017) With a rate of epidemiology occurrence that ranged from nineteen to thirty percent each month, six to forty-eight percent each year, and all times records ranged from eight to sixty-eight percent. (Littlewood et al., 2013b)

Moreover, rotator cuff tendinopathy is a quit common in United Kingdom, and Finland societies with a percentage range from 30 to 34 percent of the total population, 9 percent of them were experiencing some degree of shoulder disability. And after 3 years follow ups of the United Kingdom populations about 54 percent of them still present with the same symptoms. With working communities, the yearly recorded incidence of shoulder disorders was about 14 to 18 percent. In Washington city about 3.3 percent of all working population were complaining about non-specific shoulder disorders with an average yearly recorded incidence about 3.7 per one thousand workers, the United States of America spend about twenty thousand dollars per year on the treatment of the rotator cuff tendinopathy. (Silverstein et al., 2006) Rotator cuff tendinopathy treatment coasts in the Great Britain are about three hundred million pounds per year. (Heron et al., 2017)

Aging is significantly related to the prevalence of the rotator cuff tendinopathy that are presented without symptoms the individuals between fifty to sixty years of age have tendency to develop rotator cuff tendinopathy without symptoms by 13 percent compared to younger individuals, while the individuals above eighty years of age have tendency to

develop this condition by 51 percent over the younger ones. The ages between 58.7 and 67.8 years of age represent the average age in which healthy individuals may develop the asymptomatic rotator cuff tendinopathy. (Jeong et al., 2017)

2.2. Review of relevant anatomy of the shoulder joint and the rotator cuff muscles

2.2.1. Anatomy of the shoulder joint

To understand the rotator cuff tendinopathy first we need to understand the anatomy and the of the shoulder joint and its articulations, also we need to understand more about the bones and the soft tissue around the shoulder joint. The shoulder joint has two main motion complexes humero-acromial and scapula-thoracic movement. (Goldstein, 2004)

2.2.1.1. Bones of the shoulder joint

The main function of the shoulder joint is mobility which explains why it does not have any bony articulation with the spinal column, this is why it has an extensive range of motion compared to the lower extremity which is made mainly to maintain the weight of the body. The shoulder joint consists of three bones humerus, clavicle, and scapula as following: (Goldstein, 2004)

Humerus

The humerus is considered to be the biggest and the strongest bone of the upper limb, its upper end composed of the greater eminence, bicipital fossa, lesser eminence, and the adjacent humeral shaft. The greater eminence provides the common insertion of the tendons of the supraspinatus, infraspinatus, and teres minor muscles. While the subscapularis muscle is inserted in the lesser eminence, which all together forms the rotator cuff muscle group. The neck of the humerus is located just below the greater and lesser eminences, which is considered to be the most common site for humerus fractures due to its location. (Terry & Chopp, 2000)

Clavicle

Clavicle is a superficial prolonged bone shaped like the English letter S, and it is lined flatly throughout its distribution in the body. The inner 2/3 of its surface is curved and bowed anteriorly to clear pathway for the neurovascular bunches of brachial plexus, and it is articulated to the sternum. The lateral 1/3 it's surface is smooth and forms the acromioclavicular joint. (Goldstein, 2004) It acts as a bony pillar which stabilizing the arm on the thorax. (Felstead & Ricketts, 2017)

Scapula

The scapula is a trigonal bone that is connected to the thoracic bones by a strong muscular tissue and connected to the clavicle bone by the Acromio-clavicular joint. It has three margins and three corners. The spine of the scapula adjusted distally to form the acromion process. (Goldstein, 2004) The coracoid process of the scapula provides a common insertion and origin for a various significant muscles and ligaments. the coracoid apex provides the proximal attachment of the coraco-brachialis muscle, the biceps muscle, the distal attachment of the pectoralis-minor muscle, and the proximal attachment of the coraco-humeral and coraco-acromial ligaments. The horizontal scapular ligament connects the scapular apex to the bottom of the coracoid process. The glenoid groove forms a strong connecting surface which connects the scapula to the humerus bone. (Terry & Chopp, 2000)

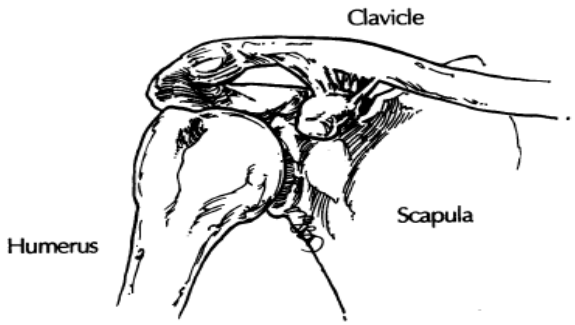

Figure 1. Humerus, scapula, and clavicle bones of the shoulder complex (Terry & Chopp, 2000)

2.2.1.2. Joints of the shoulder joint

The shoulder complex consists of four articulations sternoclavicular, acromioclavicular, glenohumeral, and scapulothoracic joints as following: (Felstead & Ricketts, 2017)

Sternoclavicular joint (SC)

The sternoclavicular joint represents the only bony connection to thorax. It has two freedom motion degrees and a tight capsule is responsible for the stability of the joint which is reinforced by the superior inter-clavicular ligament, posterior sternoclavicular ligament, and the costoclavicular ligament; which prevent the upward movement, and the rotational movement of the clavicle, and forms the center of the movements of the sternoclavicular joint. The joint weakest point is anterior surface. (Goldstein, 2004)

Acromioclavicular joint (AC)

The AC joint has capsule is weak and very susceptible to injuries. The coracoclavicular ligament is the main stabilizing structure for AC joint, it is divided to conoid ligament which serves as a fulcrum for the rotation of the scapula. The Triangular part of the ligament is attached to the medial aspect of the upper area of the coracoid process, and functions as similar to the function of the conoid ligament in the scapular rotation but in the horizontal direction. Together these ligaments allow the clavicle and scapula to moves in harmony as one unit. (Goldstein, 2004)

Scapulothoracic joint

Scapulothoracic joint is not an actual joint, which has a limited ROM because its gliding movement between the anterior area of the scapula and the thorax. The inner surface of the scapula involves the origin of the subscapularis muscle and medial border of the scapula forms the serratus anterior insertion. There 17 muscles are inserted or rises from the

scapula to provides the stabilization to the scapula and facilitate its normal movement, 4 or sometimes 5 of them are the rotator cuff muscles group. (Terry & Chopp, 2000; Goldstein, 2004)

Glenohumeral joint

The glenohumeral joint is a spheroid synovial type joint, which links the proximal part of the humerus to the glenoid groove. The proximal end of the humerus has a bigger surface area in comparison to the glenoid groove of the scapula. The typical anatomic location of the glenohumeral joint is formed when the proximal end of the humerus is positioned in an upward, proximal, and backward encountering the lesser tubercle anteriorly and the greater tubercle on the lateral side. the biceps long head tendon lays in the bicipital groove between the two tubercles. (Goldstein, 2004)

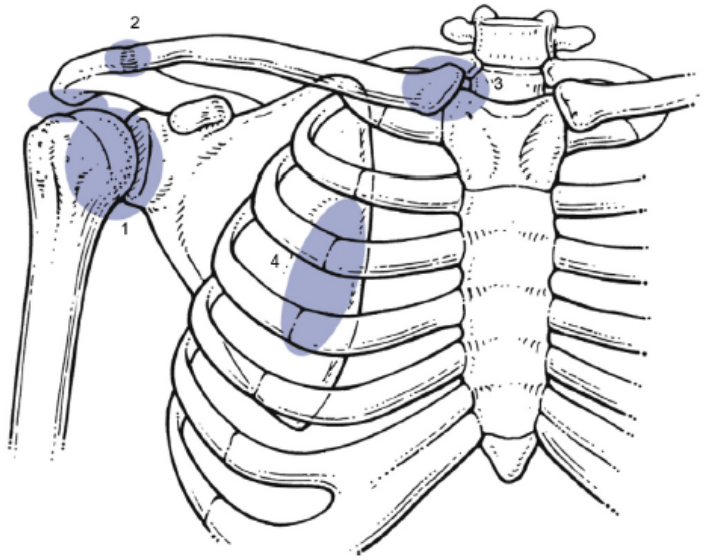

Figure 2. Articulations of the shoulder joint; I. Gleno-humeral joint, II. Acromio-clavicular joint, III. Sterno-clavicular joint, IV. Scapulo-thoracic joint (Felstead & Ricketts, 2017)

2.2.2. Anatomy and of the rotator cuff muscles

As mentioned it is very important to know the anatomy and the of the rotator cuff muscles and the embracing structures that may affects their function, not only in diagnosing of rotator cuff tendinopathy but also in treating them clearly. The rotator cuff is a group of four muscles; the subscapularis, the supraspinatus, the infraspinatus and the teres minor, these muscles enclose the proximal humeral end, and the shoulder capsule from the top front in a way that helps the shoulder medial and lateral rotation motions. (DeFranco & Cloe, 2009; Alford, 2008; Smith & Smith, 2010) These muscles as a group are originating from their fossa's except for the teres minor which originates from the middle 1/3 of the postro-lateral line of the scapula, together these muscles form one bundle that is inserted on both tubercles of the humerus. (Vollans & Ali, 2016) Actually the term (rotator cuff) may be not the most suitable name to describe these group of muscles regarding their primary role in stabilizing the shoulder by pressing the humeral head down and compressing it towards the center of the joint to give it a fixed point for the upper limb motion with the help of the long head of biceps, (Alford, 2008; Wells et al., 2016) despite the fact that each of these individual muscles has the ability to rotate the humerus medially and laterally according to their anatomical position in the upper extremity. (Vollans & Ali, 2016)

Subscapularis

The subscapularis muscle originates from the subscapular fossa in the dorsal aspect of the scapula, and inserted in the lesser tubercle of the anterior aspect of the humerus, Small portion of the muscle is inserted on the humerus about two centimeter lateral to the lesser tubercle. Both upper and lower terminals of the subscapular nerve C5-C8 provides the innervation for this muscle. The subscapularis is considered to be the only muscle from the rotator cuff group that is inserted in the anterior (frontal) part of the humerus. Its function is to provide the medial rotation for the glenohumeral joint; besides its main role as a rotator cuff muscle in providing the active and passive fixation to frontal glenohumeral gliding motion due to its high collagen fibers inside structural part of the muscle, and also it is supported by the strong middle and lower glenohumeral ligament tendons. The distal one

third of its tendon insertion has also a major role in fixating the proximal part of the tendon long head of the biceps brachii. (Malcarney & Murrell, 2003)

Supraspinatus

The supraspinatus muscle emerges from the supraspinatus fossa of the scapula and attached to the greater tubercle of the humerus. The uppermost fibers of the muscle are aligned in longitudinal direction, while the lowermost fibers are aligned in horizontal direction. The nerve supply for this muscle is provided by the suprascapular nerve C4-C6. Its function is to start the arm abduction and stabilizing the shoulder joint by pressing the proximal end of the humerus into the glenoid cavity as in a conjugation force process. About 15 millimeters near to the distal attachment, both of the supraspinatus and the infraspinatus muscle tendons emerges together as one tendon. (Malcarney & Murrell, 2003)

Infraspinatus

The infraspinatus muscle arises from the infraspinatus fossa of the scapula and attaches to the same insertion point of the supraspinatus tendon which is the greater tubercle of the humerus with. It is also innervated by the same innervation of the supraspinatus muscle which is the suprascapular nerve C4-C6, as described. The infraspinatus acts as the main lateral rotator of the shoulder joint, and prevents the backward glenohumeral gliding motion. (Malcarney & Murrell, 2003)

Teres minor

The teres minor muscle originates from the middle 1/3 of the postro-lateral border of scapula and inserted in the lower portion of the greater tubercle. Small portion of the muscle is inserted on the humerus about two centimeters lateral to the greater tubercle like the subscapularis muscle. axillary neuronal branches of the brachial plexus C5-C6 provides the innervation of this muscle. The teres minor muscle functions as a lateral rotator and backward stabilization band for the shoulder joint. (Malcarney & Murrell, 2003)

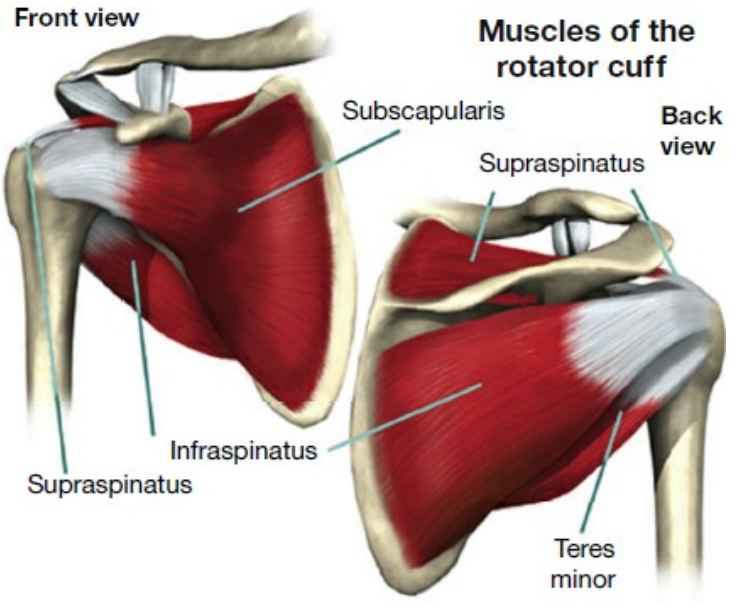

Figure 3. Alignment of the rotator cuff muscles in the body (Vollans and Ali, 2016)

Vascular supply to the Rotator Cuff muscles

Several branches of the axillary arteries provide the vascular supply for the rotator cuff muscles, includes the circumflex dorsal and frontal arm arteries, the dorsoacromial artery and the suprascapular artery. in particularly, the circumflex frontal arm artery supplies the superficial frontal rotator cuff muscles, while the suprahumeral blood vessel which is branch of the dorsoacromial artery acts as reinforcing root of vascular structures in this area, and the posterior circumflex humeral and subscapular arteries supplies the infraspinatus and teres minor muscles.

Almost all tendons of the rotator cuff muscles are not covered by an actual synovial cover, and this explains why only small branches from the arteries mentioned above are the main providers of the vascular supply for the muscles tendon which can penetrate their periosteum. (Malcarney & Murrell, 2003)

Cellular anatomy of the rotator cuff muscles

Most of the rotator cuff muscle tendons are made of water about 55 percent of the liquid components, collagen type I about 85 percent of the solid components, collagens type three and type twelve, fibroblasts, Proteoglycans, elastin, and Glycosaminoglycans, elastin. (Malcarney & Murrell, 2003)

2.3. The role of the rotator cuff muscles in shoulder stability

The rotator cuff muscles are considered to be the primary providers for the dynamic stabilization to the glenohumeral joint during the movement. (Yuan et al., 2002) The rotator cuff muscles works together to stabilize the head of the humerus and fixate it to the glenoid cavity to make sure that the head of the humerus does not slip on the glenoid cavity specially during shoulder (arm) elevation, this mechanism is known by concavity pressing. Moreover, in this mechanism the subscapularis, the infraspinatus, and teres minor these three muscles act mainly in preventing the frontal and dorsal translation of the head of the humerus on the glenoid cavity. These mechanism makes the rotator cuff muscles functions in an organized rhythm during almost all movement of the shoulder. However, each muscle is able to preserve its unique function when needed. (Vollans & Ali, 2016)

2.4. Rotator cuff tendinopathy and its classification

Rotator cuff tendinopathy is considered to be one of the most common orthopedic pathologies (Leong et al., 2017; Merolla et al., 2013) about ten patients per one thousand rotator cuff tendinopathy patients are represent clinically with shoulder discomfort, and about 74 percent of them reports having a signs of developing shoulder impairments and limitation, and 85 percent of these patient reports having signs of rotator cuff muscles tear. (Choo et al., 2014)

Tendinopathy is a clinical term that is used to describe all kinds of tendon pathology that caused by both structural and functional changes that involves a series of wide range

clinical presentation which can be graded from a mild inflammation as in rotator cuff tendonitis/tendinosis, subacromial bursitis, and calcification of the rotator cuff tendons, to more serious conditions as in degeneration of the rotator cuff tendons, and/or partial and complete rotator cuff tears. (Desmeules et al., 2016; Littlewood et al., 2013a; de Oliveira et al., 2017a; Mallows et al., 2017) However, the term is alternatively used to describe tendinitis and tendinosis. (Sejersen et al., 2015)

2.4.1. Classification of the rotator cuff tendinopathy

Rotator cuff tendinopathy could be classified into four major classifications according to the nature of the pathology: traumatic, underloaded, reactive, and degenerative classification. (Uhthoff & Matsumoto, 2000; Lewis, 2010)

Traumatic tendinopathy

This division of rotator cuff tendinopathy happens when there is an intense external forces applied to the rotator cuff tendon, which commonly results in a sudden pulling the rotator cuff tendon from its bony attachment. Traumatic tendinopathies are often seen in the young individual or teenage patients. These type of tendinopathies often leads to permanent changes to the soft tissue around the pulling location, causing a sever weakness in this location. An example for this type tendinopathies are (rotator cuff tears). (Uhthoff & Matsumoto, 2000)

Underloaded tendinopathy

This type of tendinopathies caused when there is insufficient stimulation (inactivity) on the rotator cuff muscles tendons. This type usually happens to the supraspinatus muscle tendon on its insertional location. In this type of tendinopathy, the involved tendon will be degenerated with the time, at this time of the pathology stays without symptoms. But If the tendon of the rotator cuff muscle receives an excessive temporal load, the tendon will response by an increasing in tendon size, and the tendon may resume to its normal size. Also

at this stage of the area stays without pain and asymptomatic. However, if the load is persisted for a long time, it will increase the pressure on the coraco-acromial ligament which is connected to the rotator cuff tendons, this persistence load will lead eventually to form a bony structure called 'acromial spurs' which is one of the main examples of this type of tendinopathies. (Lewis, 2010)

Reactive tendinopathy

This type of tendinopathies develops either gradually over time. The main example for this type is (rotator cuff calcification tendinopathy), which usually occur during the 4th and 5th decennium of age, and is rarely seen beyond the 6th decennium of age. The calcification is usually presented close to the area when the tendon connects to the bone, this calcification is composed of a fibrogenous and cartilaginous tissue. The calcifying tendinopathy is not classified as degenerative condition. (Uhthoff & Matsumoto, 2000)

Degenerative tendinopathy

This type of tendinopathy is characterized by irreversible changes, mostly at the area of the tendon insertion. Their occurrence rate elevates with age, in spite of the fact that there is no direct connection between the age and the degree of degeneration. This type of tendinopathy is often associated with arthritic changes, formation of osteophytes, and bony process formation. (Uhthoff & Matsumoto, 2000)

2.5. Etiology and pathogenesis of the rotator cuff tendinopathy

The actual etiology and pathogenesis of the rotator cuff tendinopathies is unknown. (de Oliveira et al., 2017b) However, several theories have been suggested to explain the etiology and the pathogenesis of the rotator cuff tendinopathy. A few theories suggest that the degeneration is most common cause. (Wu et al., 2015; Rudzki et al., 2008) While some other theories suggest that the development of the rotator cuff tendinopathies depends mostly on several internal and external factors either occur individually or presented together (Seitz

et al., 2011; Lewis, 2008; Lewis et al., 2009), which will be described in details in the following sections:

2.5.1. Internal factors

Internal factors of rotator cuff tendinopathy mainly related to the tendons creation and action. There are many several Internal factors contribute to the development of rotator cuff tendinopathy which lead to the deterioration of its tendon as a consequence of the continues aging process, insufficient blood supply, changing biological properties, and changing in the mechanical characteristic of the tendons which result in the tendon damage as a form of deterioration over the time. The genetic factor also has a role in development of the rotator cuff tendinopathy in form of mutation in the genomes of the collagen tissue which also can be seen in the Achilles tendon pathologies; although, there is no special gene has been found to be responsible for causing of rotator cuff tendinopathy. (Sejersen et al., 2015; Rabini et al., 2012; Factor & Dale, 2014; Seitz et al., 2011; Firat & Türker, 2012) However, the internal factors of the rotator cuff tendinopathy are divided to four main categories which are discussed in details in the following subdivisions:

Degenerative aging effects

The researcher Codman were the first who noticed the degeneration that affects the tendons structures which is developed in the supraspinatus tendon pathologies; he also subdivided the development of rotator cuff tendinopathy in relation to the age into 3 phases: if the pathology occurs in earlier than twenty five years of age the pathology is considered as phase one, if it happened between twenty five and forty years it is considered as phase two, and if it happened in the age older than forty years of age it is considered as phase three.

Aging has been noticed to have a damaging influence on tendon over the time, represented as a decreased stress tolerability curve, reduced elasticity, and diminished overall tensional strength of tendons. A study has noticed the development of calcification of the rotator cuff tendons while in the older patients with rotator cuff tendinopathy, and they

didn't notice in the younger patients, both groups are without any history of shoulder injuries. Furthermore, aging has also a significant effect in reducing the total amount of the glycosamino-glycans and proteo-glycans molecules in the supraspinatus tendon, general decreasing collagen molecules, and increasing the type three collagen. However, some theories attribute these changes that happened to the supraspinatus tendons are not caused by the senility process but are caused by the healing process as a consequence to the micro-trauma that happens to the tendon. (Seitz et al., 2011)

Insufficient blood supply to the tendons

Manifested in an area called the (critical area) in the rotator cuff muscles, which is that distance from the supraspinatus tendon located distal from its insertion by 1 centimeter, this area is characterized with a reduced blood supply, and it is the most common location for developing rotator cuff tendinopathy. Moreover, due to this insufficient blood supply there is a decreased rate of healing in this area which increases with age, this characteristic has a significant effect on the development of the rotator cuff tendinopathy. (Seitz et al., 2011)

Research have noticed this mechanism usually occurs in the chronic rotator cuff tendinopathy. The role of blood supply as an internal factor attributing the rotator cuff tendinopathy is not fully studied and need more researches focusing on studying this factor. (Seitz et al., 2011)

Changes of the tendon matrix and its influence on mechanical properties

The tendon matrix term is related to the morphological and mechanical characteristics of tendons. The tendons consist of collagen and tenocytes and proteins. The collagen tissues that contribute in the formation of the tendon are consisting of type one collagen which is a strong, rigid type of collagen tissue, and of type three collagen fibers which are finer, softer type of tissue. Furthermore, type three collagen fibers are believed to be more durable than the type one fibers and they are prone to be more distributed in irregular

form, according to some authors the degree of collagen distribution are highly diverse tissue and a distributed in low percentage in the area close the tendon attachment to the bone, which lead to decreased mechanical characteristics in this area. (Seitz et al., 2011)

Several researches that have tested the change in the rotator cuff tendon matrix, and they have found that there was no change in the total Glycosaminoglycans concentration and Proteoglycans levels, also there was a significant decrease in total collagen levels, more tenocyte apoptosis, and an elevated levels of type three collagen tissues in patients with chronic rotator cuff tendinopathies. (Seitz et al., 2011)

On the other hand, the supraspinatus tendon seems to have a bigger amount of collagen matrix in comparing to the other rotator cuff tendons, which makes it more susceptible to develop the condition of the rotator cuff tendinopathy. Furthermore, tendon matrix is prone to change depending on the duration of pathology. If the pathology in the acute stage there will be an increasing in tendon hardness combined with increased healing ability of its matrix, while in the chronic stage of the pathology there is decreasing in the tendon hardness combined with decreased healing ability of its matrix. (Seitz et al., 2011)

Mechanical reaction of the soft tissue to the load

This factor is better to be explained in the area of the supraspinatus tendon close to its insertion are found to have a decreased tolerability to stress and the vertical loading in comparing to its origin. This phenomenon usually occurs when the upper extremity is fixed in the start position of the arm elevation approximately around 30 – 62 angel degree of abduction. This phenomenon is believed to causes increasing in the friction between the rotator cuff tendons leading to the degradation of the tendon soft tissue over the time, this phenomenon also it can be found in all the other rotator cuff muscles. (Seitz et al., 2011)

There are other factors that attribute the development of the rotator cuff tendinopathy regarding the reaction of the tendons or the soft tissue to the load, represented in the irregularity and thinning of the geometrical abilities of the tendons which is responsible for

the changing that occur to its mechanical characteristics to handle the load (stress). These changes often lead to changes in the regulation and the hardness of the tendons which as a result eventually will cause the condition of rotator cuff tendinopathy. (Seitz et al., 2011)

2.5.2. External factors

There are some studies that refers the external factors contributing the development of the rotator cuff tendinopathy to the decreasing in the subacromial structural area which often cause compression on the rotator cuff structures, the existence of 3 types of the acromion bone, micro-injury, work-related mechanical loads, as a consequence of developing faulty posture problems as in changed humeral or scapular motions, and insufficient muscle stimulation. (Desjardins-Charbonneau et al., 2015; Sejersen et al., 2015) while other studies divide the external factors to three main subdivisions which will be discussed in the following section:

Structural factors

There are multiple anatomical factors contributing to the development of the rotator cuff tendinopathy such as reduction of the subacromial area which can be a result of structural acromial abnormalities or changes of the acromial angulation or the formation of osteophyte in the lower border of the AC joint or the coraco-acromial ligament. The variation of the acromion shape is divided into 3 types, Type one (plan shaped), Type two (curve shaped), or Type three (hook shaped); Type three, or hook type acromion is the most severe type, the patients with this type of the acromion have greater susceptibility to develop rotator cuff tendinopathy, while the patient with Type one acromion appears to have faster recovery. On the other hand, the deformities in the acromial shape can be born with or developed with bad habits and ergonomics. (Seitz et al., 2011)

Other structural factor which is considered also one of the most common external factors contributing the development of the rotator cuff tendinopathy is the deterioration that affects the acromioclavicular joint, which is characterized by also reduction of the joint area,

formation of bony prominence on the lateral end of the clavicle and the acromion bones, and the Formation of bony prominences on the lower surface of the lateral division of the clavicle. (Seitz et al., 2011)

Effects of scapular rhythmic movement, posture, muscle activity and soft tissue contractures

Scapular rhythmic movements deficits are found in the individuals with rotator cuff tendinopathy. Moreover, individuals with subacromial impaction tend to have reduced backward scapular motion, reduced scapular elevation, and raised medial rotation. This incidence may lead to inability of the anterior surface of the acromion to retrieve upward making enough space for the humeral head to glide downward during shoulder abduction which eventually lead to compression on the rotator cuff tendons this phenomenon called 'rotator cuff Entrapment'. (Seitz et al., 2011)

In spite of that, according to some studies that focused on the shoulder mobility in the patient with rotator cuff tendinopathy they found that a small group of the patients participated have developed defects on the scapular rhythmic motion. However, the process which responsible for the change in the scapular rhythm in the individuals with rotator cuff tendinopathy is not fully understood. on the other hand, there are some theories that refer this process to several causes such as: pectoralis minor contractures, blockage of the posterior aspect of the shoulder, functional abnormalities of the rotator cuff muscles, abnormal scapular motions, and abnormal thorax kyphosis. (Seitz et al., 2011)

Contracture of the pectoralis minor muscle is found to promote scapular medial rotation during shoulder abduction and reduces the depression of the scapula during 80 to 120 degree of shoulder elevation when compared to healthy individuals, which is believed that it is with the time this phenomenon will assist in developing rotator cuff tendinopathy. Abnormal rotator cuff and scapular activities are found to be connected to the activation level of the serratus anterior, and the trapezius muscles. Patients with rotator cuff tendinopathy tend to have reduced activation of the of the serratus anterior muscle and the

lower trapezius muscle which result in an increased load on the rotator cuff muscles and change in the scapular behavior to the movement, which also are found to be linked with the development of the rotator cuff tendinopathy. (Seitz et al., 2011)

Kyphosis of the thorax are found to be combined with a reduction in the subacromial joint area, and the reduction of the scapular depression movement. These changes in the subacromial joint area are also found to be indirectly related to developing the condition of the rotator cuff tendinopathy. (Seitz et al., 2011)

Effects of humeral rhythmic movement, posture, muscle activity and
soft tissue contractures

Massive translation of the humeral head on the glenoid cavity during active movement are found to decrease the subacromial joint space, which attribute to the development of the rotator cuff tendinopathy. Additionally, individuals with rotator cuff tendinopathy demonstrate a larger superior migration of the humerus from the healthy individuals by 1.0 to 1.5 millimeters, and 3 millimeters larger anterior margin of the humerus with the active shoulder abduction in comparison to the healthy individuals. The reason for this phenomena thought to be caused by the tightening of the postroinferior capsule of the shoulder joint, and/or reduction of the rotator cuff muscles activity specially the supraspinatus, subscapularis, and infraspinatus muscles. Alternatively, this reduction of the rotator cuff muscles activity is a consequence of pain, changed location or motion of the scapular blade or humeral head, alteration in the muscle lengthening and tensioning relations. (Seitz et al., 2011)

2.6. Predisposing risk factors of the rotator cuff tendinopathy

There are several predisposing risk factors that found to increase the incidence of the rotator cuff tendinopathy in the healthy individuals for example: getting older, metabolic conditions, smoking, psychological status, work load, frequent mechanical stress, and

presence of previous trauma in the healthy people history, etc. (D'Addona et al., 2017; Longo et al., 2010) which will be discussed in brief in the following section:

Age

Getting older is corresponding to the development of the rotator cuff tendinopathy Relatively, aging is found to be more related to rotator cuff pathologies among all of the shoulder pathologies. (Sayampanathan & Andrew, 2017).

Family history

Researches showed that there is a strong corresponding relation between the individuals who have a family history of rotator cuff tendon pathology with the developing of compressive neuropathology, and rotator cuff tendinopathy. The risk is considered to be high if the wife, the husband, or the 1st degree family members are in living in the same environment and had suffered from a rotator cuff tendinopathy in their past. The same situation applies for the individuals who have a 3rd degree family members that had suffered from a compressive neuropathology in their past. (Tashjian et al., 2016)

Gender

women that have whiter skin color are more susceptible to develop a rotator cuff pathology, specially the tendinopathies in comparison to men with the same skin color (da Rocha Motta et al., 2014)

Genetics

In a study made by da Rocha Motta et al. (2014) investigating the influence of six genomes types such as Defensin-Beta one, Fibroblast-Growth Factor three, etc. in a group of four hundred and ten patients with a rotator cuff tendinopathy. They found that there is a

strong relation between the presence of these genomes and the development of the rotator cuff tendinopathy.

Smoking

Tobacco smoking has been found to attribute the developing of the rotator cuff tendinopathy conditions. According to some studies the individual who are smoking on the long term periods will eventually develop deterioration in their rotator cuff tendons in comparison the individuals who don't smoke as a daily Routine. (Baumgarten et al., 2010; Carbone et al., 2012)

Moreover, the presence of the smoking in the patient history has been found have a strong influence on developing the condition of complete rotator cuff tears and the condition of rotator cuff calcification tendinopathy in comparison the people who don't have a smoking habits in their past history. (Zumstein et al., 2017; Oudelaar et al., 2015; Sayampanathan & Andrew, 2017) In addition, smoking on the long term are found to be a common risk factor for the development of the one-sided rotator cuff tendinopathy. (Rechardt et al., 2010)

Diabetes mellitus

Diabetes mellitus is believed to be one of the most common health condition over the world, and it has a strong influence on the patient's body specially on the small and the large blood vessels, the neurons, the soft tissue. relatively, according to some authors they found that there is a strong connection between the diabetes mellitus and the occurrence of the rotator cuff pathology, especially in the patients presents with complete rotator cuff tears. (Zumstein et al., 2017) This might be due to poor blood flow and the incomplete healing in response to the recurrent micro injury to the rotator cuff tendons which is commonly seen in the patients dealing with the diabetes mellitus. (Huang et al., 2016) Additionally, others suggest that most of the patient with insulin dependent diabetes mellitus are prone to develop chronic conditions of the rotator cuff tendinopathy. (Rechardt et al., 2010)

Obesity and body mass index

Truncal obesity and higher Body mass index is a considered to be one of the most serious risk factors that are connected with one-sided rotator cuff tendinopathy. (Rechardt et al., 2010) While others suggest that obesity is associated with two-sided rotator cuff tendinopathy in both genders. (Abate et al., 2017) Others found that there is no relation between the obesity and the side that may develop the condition of the rotator cuff tendinopathy. (Gumina et al., 2014) The incidence is high in both genders between 53 and 77 years of age who are suffering from obesity. (Wendelboe et al., 2004) However, the relationship between obesity and tendinopathies is still need more investigation. (Franceschi et al., 2014)

Psychological factors

Stress, anxiety, fear, and other Psychological factors are found to be in a strong relation with the development of Chronic the rotator cuff tendinopathy and shoulder disorders. (Bodin et al., 2012a)

Working demands

There are work related risk factors that attribute the development of the rotator cuff tendinopathy, repeated and maintained upper-limb elevation is considered the most common work related risk factor. (Bodin et al., 2012b; Roquelaure et al., 2011)

For working men population, working with repeated and fixed body posture with the upper-limb above the head more than two hours per day is a high risk factor to develop the rotator cuff tendinopathy, especially the construction workers, truck drivers, store employees, and car mechanics.

And for working women population, working with repeated and maintained shoulder abduction (between 60 to 90 degree of shoulder abduction) are found to be in a high risk for

the development of the rotator cuff tendinopathy. Especially the hospital cleaning workers, office workers, shops accountant, food, and drinks servers, and shoes cleaners. (Bodin et al., 2012b)

Cardiovascular factors

Cardiovascular pathologies such as having a history of abnormal elevated blood pressure, (Djerbi et al., 2015; Sayampanathan & Andrew, 2017; Gumina et al., 2013) and arterial blockage. (Rechardt et al., 2010) have shown a strong influence on the development of the rotator cuff tendinopathy, and rotator cuff tears in comparison to the healthy individuals.

Effect of Alcohol drinking

According to some researches the consumption of more than three alcohol drinks for men and two alcohol drinks for women per day is considered to be one from the high risk factors to develop a rotator cuff tendinopathy. Furthermore, the more alcohol consumption per day the more severe will be the damage that affects the tendons of the rotator cuff muscles. (Passaretti et al., 2016; Djerbi et al., 2015)

Handedness

Handedness may be a contributing factor with developing the condition of the rotator cuff tendinopathy on the dominant hand side. (Sayampanathan & Andrew, 2017; Yamamoto et al., 2010)

2.7. Calcific rotator cuff tendinopathy

Rotator cuff calcifying tendinitis is one of the most common painful condition that affects the rotator cuff muscles. The incidence of this condition in the healthy societies is between 2.5 and 7.5 percent. the prevalence of this condition increases in the in the

Caucasian societies ranged from 2.7 to 22 percent, this disorder usually affects females between the age of thirty and sixty years of their life span by 2 times higher rate than men in the same age. In most of the cases the calcification is usually found in the area before the insertion of the supraspinatus tendon (about 80 percent of the patients), the infraspinatus tendon (about 15 percent of patients), and the subscapularis tendon (about 5 percent of the patients). (Oliva et al., 2011; Serafini et al., 2009) One of the most common predisposing risk factors for the development of the rotator cuff calcifying tendinopathy is the repeated arm abduction over the head during the activities of daily living (ADL) and sports. (Hofstee et al., 2007)

The pathogenesis of the rotator cuff calcific rotator cuff tendinopathy is still unknown. From the first point of view this condition can be mistakenly represented as calcific enthesis pathology of the rotator cuff tendons. However, the rotator cuff calcific tendinitis is a totally different condition. (Sconfienza et al., 2013) Relatively, the development of the rotator cuff calcifying tendinitis can be divided into four phases; the 1st (pre-calcification phase) starts with the enlargement of the fibro-cartilaginous fibers in the area that placed in about 1 centimeter medially to the supraspinatus bony attachment. The 2nd (calcification phase) is the phase where the calcification starts to form inside the tendon of the muscle. While in the 3rd (reabsorptive phase) these calcifications are reabsorbed by the sub-acromial bursa. In the final 4th (post-calcification phase) the healing and the repairing process of the rotator cuff starts to takes place as soon as the phase three ends. This phases can be occurred repeatedly in rotation over time with the acute cases while the tendon has the ability to heal itself. But, in chronic cases this rotation can be disturbed at any phase. (Hofstee et al., 2007; Serafini et al., 2009)

2.8. Rotator cuff tears

Rotator cuff tear is a common disorder in the working populations, with increased prevalence rate about 13 percent in people from fitty to fifty-nine years of age, and 37 percent in the people above eighty years of age. As for the incidence of the rotator cuff tears a study of four hundred village peoples using ultrasound technique at the first visit the examination

there was no sign of rotator cuff tear, but after three and half years about thirty persons of them have developed a complete rotator cuff tear. (Zumstein et al., 2017) Relatively, only third of the rotator cuff tears cases have experienced pain, while two third of the cases have not experienced pain. And only about 20 percent of the cases who experience the glenohumeral pain seeks the medical care; that's mean for each patient that seek the clinical care there are four more patients with a painful rotator tear, and ten more patients without pain that do not visit the medical care facilities. (Itoi, 2013)

Moreover, the rotator cuff tears can be classified according to the tear length, and the existence of shoulder arthrosis into four grades; 1st Grade, incomplete tears or that measures less than 1 centimeter in the anteroposterior view, 2nd Grade, presented as complete tear of entire supraspinatus muscle about two centimeters anteroposterior view, 3rd Grade, includes complete tears of more than one tendon, 4th Grade, bigger complete tears that usually combined with arthritis of the shoulder joint. (Patte, 1990; Millett & Warth, 2014)

2.9. Signs and symptoms of the rotator cuff tendinopathy

In the acute period of the pathology; most of the patient that are developing the rotator cuff tendinopathy do not experience any symptoms, which is maybe due the progressive nature of the pathology in which the symptoms are developed rapidly over the time, a recent study showed that in order for rotator cuff tendinopathy to produce a painful symptoms it has to stimulate the mechanical alteration inside the tendon of the rotator cuff muscles, and also increases the sensibility of the peripheral nociceptive tracts to stimulate the central nervous system to trigger the painful symptoms for in the patients. (Dean et al., 2013)

Thus, that's why most of the patients in this stage do not feel any inconvenient symptoms. While, as mentioned in the previous section that most of the patients seek for the medical and professional care after they reach the chronic period of the pathology and stars to develop painful symptoms such as: swelling around the shoulder joint, subsequent pain, weakness of the affected rotator cuff muscle group, stiffness and impairment in overhead

movements, and limitation in the Activities of daily living (ADL). (Parle et al., 2017; Rabini et al., 2012) these symptoms will often fade on its own over the time, but if not treated properly it will begin to recur over and over again due to the nature of the pathology which can be affected by the over loading and the repeated faulty postures. (Scott et al., 2013)

2.10. Diagnosis of the rotator cuff tendinopathy

Diagnosis of the rotator cuff tendinopathy requires numeral consecutive procedures. Starting with the patient initial clinical anamnesis in which we ask the patient about his/her history of the symptoms, any present or past related health issues, and we must gather information about the pain, activities of daily living limitation followed by assessment of the functional limitations such as range of motion (ROM) assessment, glenohumeral capsular assessment, and manual muscle test (MMT). However, we should not focus only in the assessment of the patient affected upper extremity, but we should also look for any Painful signs, weakness, and limitation of the ROM in the lower limbs or torso that may have an influence on the involved (affected) patient shoulder to eliminate any other suspected diagnosis. Also we must not forget the important role of the imaging method such as magnetic resonance imaging (MRI), ultrasonography (US) in the diagnosis of the rotator cuff tendinopathy due to its accuracy and the valuable information that this tools provide. (Lewis et al., 2015)

2.10.1. Patient History

From the patient history the examiner should look for pain on the AC joint, pain on the side of the patient neck, pain in the outer area of the shoulder on the same side, and pain in the anteromedial surface of humerus on the affected side, all of this pain types are considered as signs for developing a rotator cuff tendinopathy. (Itoi et al., 2006)

2.10.2. Imaging methods

Diagnostic ultrasound (US) and Magnetic resonance imaging (MRI) are the most common imaging methods that used in the clinical diagnosis of the rotator cuff tendinopathy to confirm the result of the clinical orthopedic tests, and to locate the calcification or the thickening or any other structural change that may affect the tendons of the rotator cuff muscles according to the condition of the rotator cuff tendinopathy.

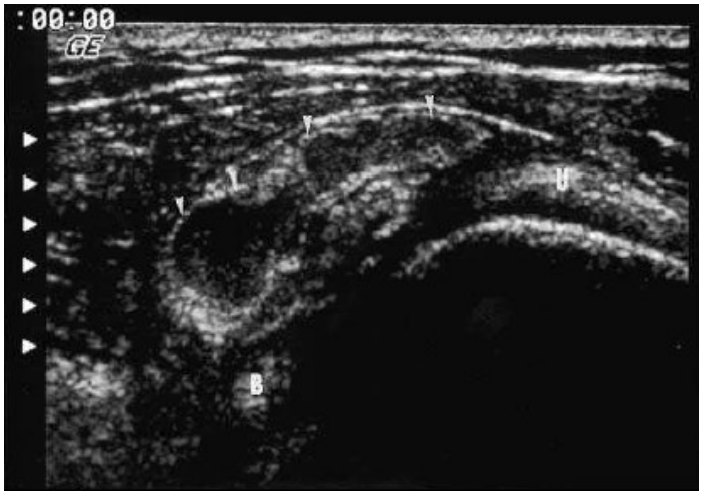

Figure 4. Calcification of the supraspinatus and the subscapularis as marked by the arrows in US image (Chiou et al., 2012)

The preference to use one method (from US, or MRI) over the other is left to the choice of the examiner on which method he/she will be using in the diagnosing process, based on his/her personal priority and experience. Several researches have assessed the validity and the reliability of US and MRI in diagnosing rotator cuff tendinopathy and they have reported that the use of US in a well-trained clinician is found to be more sufficient than MRI because the US images has more area resolution than the MRI images. (Scott et al., 2013) Relatively, MRI is the main tool that used to measure the presence of the rotator cuff tears and where it is located. While US may have a several advantage over the MRI such as it is easy to preform, which has lower costs in comparison to the MRI, and it saves the patients time because the complete US procedure takes a short period in comparison to

the MRI. (Itoi et al., 2006) However, diagnosing tendinopathy with US can be unachievable in some cases because sometimes it become difficult to differentiate between the tendon that affected by the tendinopathy and the surrounding tissues. (Lee et al., 2016)

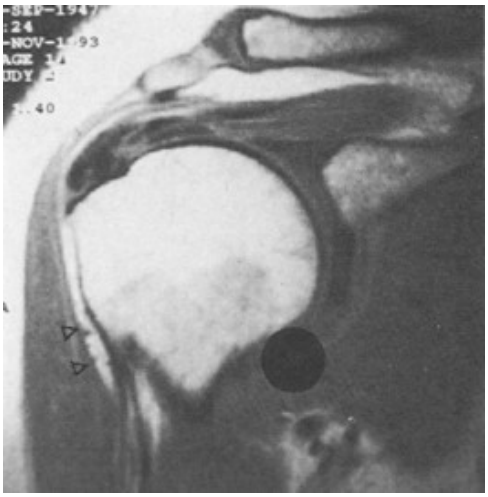

Figure 5. Type 3 supraspinatus muscle calcification showed by the arrows in MRI image (Loew et al., 1996)

2.10.3. Physical examination tests

There are various special tests that can be helpful in the diagnosis of the rotator cuff tendinopathy such as:

The supraspinatus test (empty can test)

The supraspinatus test (empty can test) is an isolation test to measure the activity of the supraspinatus muscle, the test is performed by fixing the patient arm in 90-degree adduction and 30-degree flexion with full internal rotation of the shoulder then the therapist gives the patient an isometric resistance on the patient forearm by one hand, and by the other hand the examiner fixes the patient shoulder and palpate the tendon of the supraspinatus muscle. The presence of pain during this test could be a sign of weakness of the supraspinatus

muscle, which could be a secondary to supraspinatus tendinopathy or a result of impingement of the tendon of the rotator cuff muscles. (Itoi et al., 2006)

The Neer's Test

This test is used to detect the compression on the rotator cuff tendon, which can be a result of the rotator cuff tendinopathy. First, the examiner passively fully pronates the patient arm from the side of his/her body. Then by one hand the examiner fixates the patient scapula, then by the other hand the clinician grasps the patient's forearm to make resistance against upward flexing movement. Positive result of the test is when the patient feels pain in the anterior aspect of the glenohumeral joint. We should know that this test can produce pain if the patient will also develop other conditions such as: arthritis of the glenohumeral joint, adhesive capsulitis, and bone pathologies. As for the sensitivity of the Neer's test there was one study that focused on measuring the sensitivity of this test, and it concluded it has a sensitivity of 75 percent for detecting subacromial bursitis and 88 percent for rotator cuff tendinopathy. (Wilson, 2005)

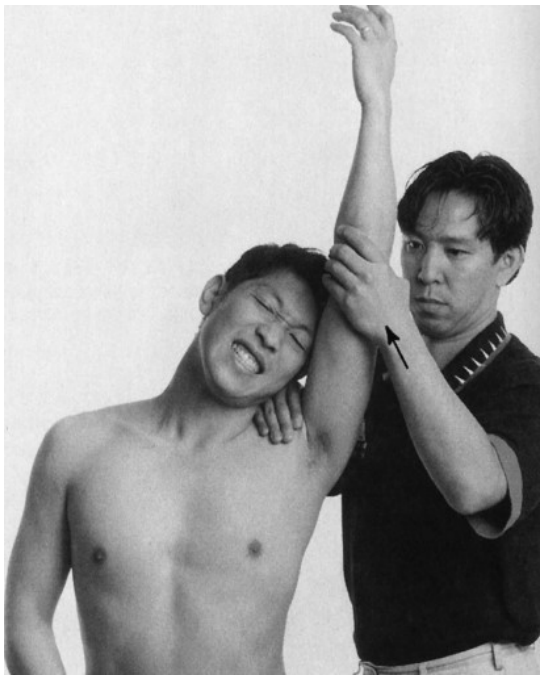

Figure 6. Neer test (Wilson, 2005)

The Hawkins' Test

The Hawkins' test was presented as a replacement to the Neer's test. In this test, the patient is asked to flex his/her arm upward up to 90º, and flexes his/her elbow also up to 90º. Then the person who is examining the patient passively rotate the humerus of the patient internally to the maximum internal rotation, the test is considered positive if the patient feels pain in subacromial area. The sensitivity of the diagnosis of this test is 92 percent for subacromial bursitis, and 88 percent for rotator cuff tendinopathy. (Wilson, 2005)

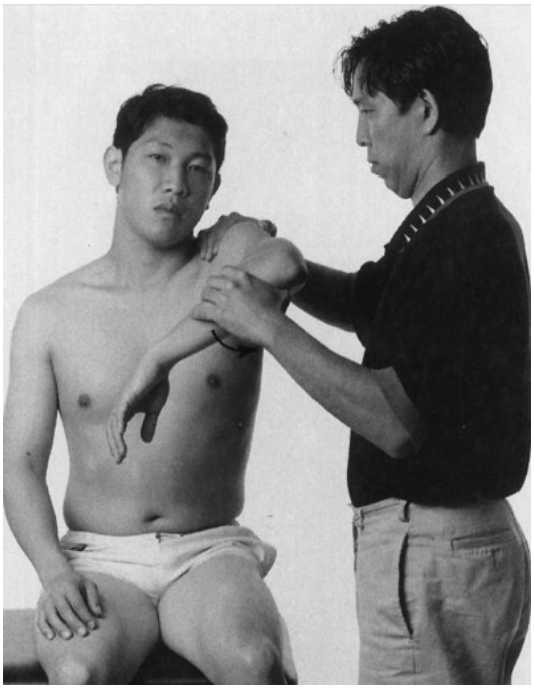

Figure 7. Hawkins' Test (Wilson, 2005)

The Jobe's Test

The Jobe's test is an isolation supraspinatus tendinopathy test, which is the most common affected tendon of the rotator cuff muscles due to its placement in the body facing the acromion. In this test the patient is asked to elevate his/her arm with the tip of the thumb facing the ground (for isolating the tendon of the supraspinatus muscle) to 90º while sitting

from the side of the body to the angle between 30-90º amidst flexion and elevation. Then the person who is examining the patient places one hand on the patient shoulder to fixate it, while by the other hand the examiner provides a mild resistance to the patient movement. Positive test is when there is pain during the movement or the inability of the patient to complete the test. (Wilson, 2005)

Figure 8. Jobe's Test (Wilson, 2005)

2.11. Management of the rotator cuff tendinopathy

The common treatment plan that used in the management process of the rotator cuff tendinopathy on its acute stage includes, elimination of risk factors, flexibility issues and biomechanical abnormalities, reduction of the patient symptoms by using anti-inflammatory medications, resting, Injection of platelet rich plasma (PRP). (Miller et al., 2017) and improving the patient function by adding static muscle stretching, and isotonic muscle strengthening training to the treatment program, (Dimitrios et al., 2014; Littlewood et al., 2012) and implication of the physical modalities such as: cold pack application, US, low level laser modality, ionto-phoresis, phono-phoresis, friction massage, and injection of cortical steroids in the affected tendon. (Woodley et al.,2007; Serafini et al., 2009; Andres & Murrell, 2008).

It is necessary to understand that the resting, cold pack application, the anti-inflammatory drugs, injection of cortical steroid, and PRP are mainly used to relief the inflammatory symptoms that may be associated with the rotator cuff calcification tendinopathy in the acute stage, and it has no benefits in the chronic stage of the disorder because at this time the pathology will be in a late stage of degeneration, and calcification. (Camargo et al., 2014)

On the other hand, physical modalities may help to improve the bio mechanical and chemical structures of the affected tendons, and it also could stimulate the fibrosis and the regeneration process. However, there isn't enough evidence that confirm this theory. (Camargo et al., 2014)

In conclusion, these common traditional treatment plans have been found to have a no significant role in treating chronic calcific rotator cuff tendinopathy. Thus, surgery and shockwave therapy seems to be a better solution for treating the rotator cuff tendinopathy. (Andres & Murrell, 2008)

2.12. Extracorporeal shockwave therapy

The Extracorporeal shockwave therapy (ESWT) are a 3 aspect pressure impulses of a short time duration it maximum pressure is between thirty-five and one hundred twenty megapascal (MPa) that transmitted with conducting medium. (Speed, 2014) These shockwaves are determined by an abrupt increase in pressure magnitude at the front wave by minimum 10 nanoseconds (Δt), a decreased tactile magnitude, a short rotational time by no more than 10 milliseconds, a wide frequency range approximately about sixteen to twenty megahertz (MHz), and a changing adverse pressure at its end.

The transmission of the shockwaves mainly relies on the materials that the waves are transmitted through. For example, if the shock waves are transmitted through the air, the shockwaves will dissolve in a short period of time. While if transmitted through liquid, the shockwaves will transmit by one thousand times shorter period than if the waves are

transmitted through the air. However, the medical using of the shockwaves is conducts the shockwaves through a liquid medium, which must be combined with placing a lubricating gel on the treated area to facilitate the transmission of the shockwaves. (Chung & Wiley, 2002)

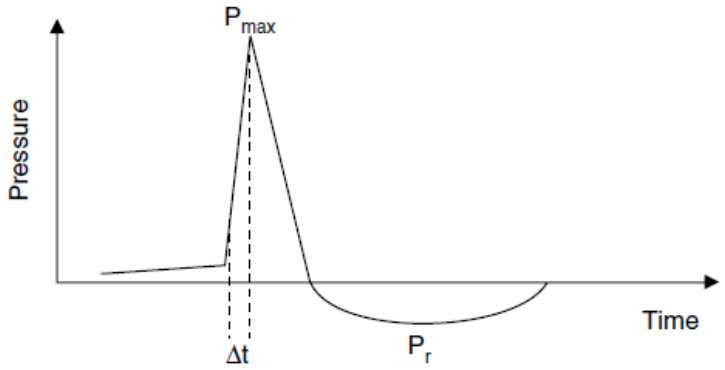

Figure 9. The unique structures of the shock-wave, Pmax: pressure highest threshold, Pr: pressure lowest threshold, Δt: acceleration velocity. (Chung & Wiley, 2002)

2.12.1. History and background

Studies on ESWT were established with a random analyzation of the osteoblast cells activity during animal experiments in the year 1980 which created curiosity in the effectiveness of ESWT in the treatment musculo-skeletal conditions. (Wang, 2012) However, the actual utilization of the extracorporeal shockwaves in the medical scope begins from the early 1985, (Wang, 2003a) as a tolerable and effective method for treating nephron, and saliva stones. Recently, shockwave is being used as a choice of treatment for a variety of medical conditions e.g. unhealed bone fractures, tendon pathologies, (Chung & Wiley, 2002) and a treatment option for the neck of femur fractures. (Wang, 2012)

Relatively, ESWT has earned remarkable acceptance in the European communities, Asia, and North America, this wide acceptance of the extracorporeal shockwaves has placed

the foundation of the International Society for Musculoskeletal Shockwave Therapy (ISMST) in the year two thousand from the last decade. (Wang, 2003a)

2.12.2. Types or classifications

Extracorporeal shockwave therapy is divided into two types as the following:

Radial extracorporeal shockwave therapy

Radial extracorporeal shockwave therapy (RESWT) was announced for the first time in the year 2001 as an alternative, efficient and easy applicable method of the shockwave therapy. It was presented as replacement to the traditional Focused extracorporeal shockwave therapy (FESWT). The radial shock wave devices are activated by air compression, then after it reaches its ultimate energy the applicator but the tip of the devices on the treated area, and at that point the effect of the shockwave become distributed into the patient tissue. The benefit of radial type of shockwave devices is that it can treat a large surface area, and it has a lower cost in comparison to the focused extracorporeal shockwave. (Lohrer et al., 2010; Gerdesmeyer et al., 2008)

Controversially, some authors believed that it is unfair to refer the RESWT to the shockwaves, because the Radial shockwaves are produced by a ballistic material and their effect is superficial, and do not operate by the same mechanisms of the medical shockwaves. (Speed, 2014) On the other hand, the RESWT have shown a noticeable success on the last few years, due to its safety, and low side effects compared to other treatment modalities. (Weckström & Söderström, 2016)

Focused extracorporeal shockwave therapy

Focused extracorporeal shockwave therapy (FESWT) is a more accurate form of medical shockwave, FESWT treats small areas about two millimeters to one centimeter area; this describes term (focused) to its name. Focused extracorporeal shockwave therapy is

different from the radial type in the shock wave generation methods, i.e. focused extracorporeal shockwaves are generated by electro-hydraulic, electro-magnetic or piezo-electric methods. (Speed, 2014)

Moreover, the extracorporeal shockwave according to the energy flow density (EFD) which measures by millijoules/mm2, and represent the unit that used to determine the stream of shockwave energy into two subdivisions: High, and Low energy ESWT, (Low energy ESWT) is equals 0.12 millijoules/mm^2 or less, while (High energy ESWT) is above 0.12 millijoules/mm^2. (Speed, 2014)

2.12.3. Mechanism of action

Currently, there are 4 major methods of shockwave conducting for medical purposes. 3 of these methods electro-hydraulic method, electro-magnetic method, and piezo-electric method, all of this methods produce shock waves for the focused extracorporeal shockwave devices, while the last method air pressure method which produces shock waves for the radial extracorporeal shockwave devices. (Chung & Wiley, 2002) each method will be described respectively on the following section:

Electrohydraulic method

This method stands for the 1^{st} generations of medical shockwave devices. in this method a high-load electrical current from a condenser is distributed through an electrode surface, these charges are steadily drained from the condenser by a full in liquid spheroidal indicator. The eventual charges then increase the temperature of the surrounding liquid and boils it, generating a vapor bubbles filled with plasma. The explosion of this bubbles produces acoustic pulses; this pulses are manifesting later to form a shockwave. The crucial volume of the electrohydraulic shockwave devices is considered to have a quite large central diameter, and elevated overall energy. (Ogden et al., 2001)

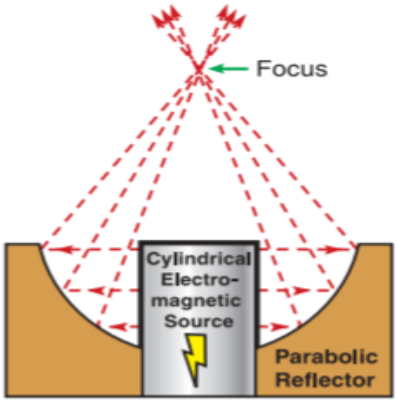

Figure 10. Electrohydraulic method (Cleveland & McAteer, 2012)

Electromagnetic method

In this method the machines are provided with an electromagnetic loops aligned in front of a metal plate. this loops have a high frequency electric current that is passing through it, which in turn creates a powerful magnetic scope. This magnetic scope then pushes the metal plate away from the loops which compress the liquid that encompassing it to create the shockwaves. These shockwaves are then transferred to a lens, which in turn works to summon the shockwaves into a small focus point. Moreover, in this method the diameter of this point is determined by the size of the lens. (Ogden et al., 2001)

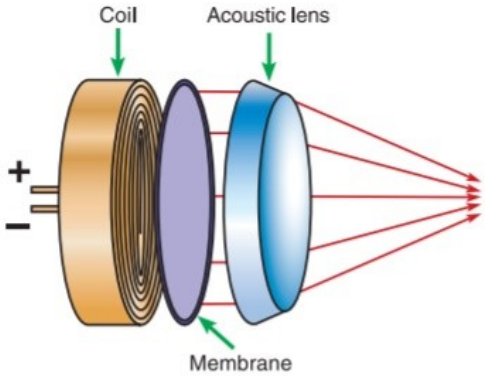

Figure 11. Electromagnetic method (Cleveland & McAteer, 2012)

Piezoelectric method

In this method the source of the shockwaves is represented by about more than one thousand piezo crystals that undergoes an electrical current, and placed inside an ellipsoidal shaped space. This electrical current makes the crystals in continuous compression and decompression state which then, cause a pressure on the encompassing water, which in turn produces the shockwaves. In this method the shockwaves are more elicit and focused in comparison to the previous types that mentioned before. (Ogden et al., 2001)

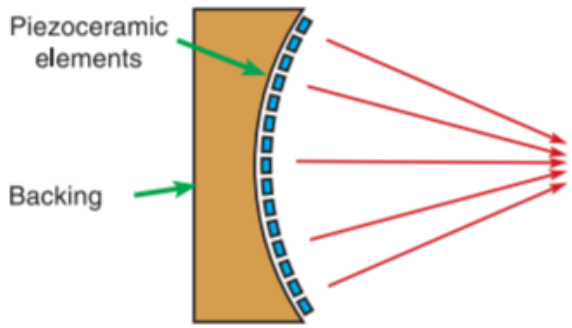

Figure 12. Piezoelectric method (Cleveland & McAteer, 2012)

Air pressure or ballistic method

In this method shock waves are created by increasing the speed of a small ball to stimulate an amplifier to the head of the shockwave device, which in turn transforms into shockwaves. (Gerdesmeyer et al., 2008)

2.12.4. Therapeutic Effects

The therapeutic effects of the ESWT are still not cleared yet. The general therapeutic effects of the ESWT includes: reducing the pain and that is associated with the musculoskeletal pathologies, by changing the membranes permeable adaptation of the nociceptive cells. This effect usually in the short period application of the ESWT, and not

for the long durations, Additionally, the ESWT has an effects on the blood vessels in the treated area which manifested in vasodilation of the blood vessel walls, which has an effect in increasing the blood flow to the treated area, and speeds up the healing process. (Chung & Wiley, 2002) While the therapeutic effects of the radial extracorporeal shockwave therapy (RESWT) are not fully understood. However, some researchers believed the (RESWT) has a role in speeding the soft-tissue healing process, and to inhibit the pain experience by interrupting the pain gait theory. (Weckström & Söderström, 2016) Furthermore, the majority of the studies and researches that have been done on the extracorporeal shockwave therapy during the years have given a positive feedback about the effectiveness of ESWT. However, there are some studies which states that the ESWT is not effective or has insufficient effect to produce therapeutic effect. (Wang, 2012)

2.12.5. Indications (clinical uses)

The use of the extracorporeal shockwave therapy (ESWT) has shown a wide success in the treatment of several medical conditions such as: long bones fractures nonuniouns, calcifying tendinopathies, plantar fascia inflammation, and lateral epicondyle inflammation (tennis elbow). Recently, the use of (ESWT) has been expanded to treat other medical conditions such as: femoral head avascular necrosis conditions, patellar tendon inflammation (jumper's knee), osteochondritis dissecans (OCD), non-calcifying tendinopathy, golfer’s elbow, trochanteric bursa inflammation, (speed, 2014; Rasmussen et al., 2008) iliotibial pain syndrome, and hamstring tendonitis. (Weckström & Söderström, 2016)

2.12.6. Side Effects and contraindication

The most common side effects of the shockwave application include: uncomfortable pain after the therapy session, aggravation of symptoms after the treatment session for a short time, swelling, redness on the area of application, and mild paresthesia, excessive breathing, and hypertension about two hundred mmHg during the therapy sessions. (Chung & Wiley, 2002) Contraindications for ESWT includes: pregnant women, tumors, blood

clotting disorders, application over the thorax region, lungs, blood vessels and neuronal pathways. (Chung & Wiley, 2002)

2.12.7. ESWT in treating rotator cuff tendinopathy

Both types of Extracorporeal shockwave therapy (FESWT) and (RESWT) have been used to treat the rotator cuff tendinopathy. Respectively, extracorporeal shock wave therapy (ESWT) has shown successful outcomes during the last decade in the treatment of calcifying rotator cuff tendinopathy by decreasing the painful symptoms and the calcifying deposition which can be noticed with imaging methods. (Rebuzzi et al., 2008)

2.13. Surgical approach in the treatment of the rotator cuff tendinopathy

Surgical approach is usually considered the last treatment method for the rotator cuff tendinopathy after the failure of the other treatment interventions. The standard surgical approach in the treatment of this type of disorders is the open or arthroscopic debridement (removal) of the calcific deposits of the involved tendon. (Andres & Murrell, 2008)

2.14. Long term rehabilitation

The long term rehabilitation of the rotator cuff tendinopathy can be challenging (Camargo et al., 2014) However, the long term rehabilitation program of rotator cuff tendinopathy should include strengthening exercises, flexibility training, sensory motoric exercises for the stimulation and improving the deep sensation, soft tissue mobilization, and durability training. (Woodley et al., 2007)

3. Methodology

3.1. Objectives and research methods

This comprehensive systematic review compares two of the most common used treatment methods for chronic calcific rotator cuff tendinopathy by utilizing evidence from recent randomized controlled trials, prospective, and retrospective studies

3.2. Aim of the thesis

The main goal of this research is to compare the efficiency of extracorporeal shock wave application and the surgical approach in patients with calcific rotator cuff tendinopathy.

3.3. Research questions

1. Which one from the Extracorporeal shockwave therapy and the arthroscopic intervention can provide faster and more efficient result in reducing pain and improving shoulder function in patients with calcific rotator cuff tendinopathy?

2. Which one from the Extracorporeal shockwave therapy and the arthroscopic intervention has higher advantageous in treating calcific rotator cuff tendinopathy patients?

3.4. Criteria of the research

3.4.1. Types of studies

Randomized controlled trials, prospective studies, and retrospective case series studies published between 2000-2018 years and carried out in Europe, United Kingdom,

Northern America, Near (Middle) and Far East. Moreover, all the studies and the clinical trials that preformed before the year 2000 were excluded from this study.

3.4.2. Languages

All the Studies which used in this research are originally in English language or translated to English. Moreover, all the studies that are presented in other languages than English are excluded from this research.

3.4.3. Types of participants

Patients of all ages, and both genders (Male and Female) participants were included in in this study.

3.4.3. Types of pathologies

Chronic conditions (with at least 3 months' duration of the symptoms) of calcific rotator cuff tendinopathy were the only type of pathology that included in this study.

3.4.4. Types of interventions

For extracorporeal shock wave therapy both (Radial, and Focused) of low, medium, and high intensities were included in this research, and the arthroscopic approach was the only type of the surgical intervention which included in this study.

3.5. Outcome measures

3.5.1. The Constant-Murley Score (CMS)

The Constant and Murley shoulder score (CMS) is considered to be one of the most commonly applied scores that used to evaluate and assess the overall shoulder function. It is

widely recommended, the European Society for Surgery of the Shoulder and Elbow (SECEC) recommend to use it as one of the reliable scoring tool for the shoulder function (Yasin et al., 2010) and it is frequently used in the experimental trials (Holmgren et al., 2014) as an easy applicable, time saving tool that does not require an additional costs or complicated equipment to apply it.

The (CMS) consists of a total one hundred points scoring system. distributed into subjective measurements, and objective measurements. The subjective measurements which is usually done before the objective measurements consists of a total of thirty-five points that is used to assess the pain intensity according to the patient's own feeling, and the assessment of ability of the patients to perform the ADL. While the objective measurements consist of a total of sixty-five points that is used to assess the shoulder power, and ROM using a goniometer to evaluate the flexion, medial, and lateral rotation movements of the shoulder, also in the objective measurements we should assess the hand position regarding to the head and the torso. (Constant & Murley, 1987; Yasin et al., 2010)

3.5.2. The Visual Analogue Scale (VAS)

The visual analogue scale (VAS) is the most common used subjective clinical tools that are designed to evaluate the approximated pain severity or intensity that experienced by the patients. (Carlsson, 1983) Also, the visual analogue scale is frequently used as a clinical outcome to measure the pain of the subjects in the experimental trials. The visual analogue scale consists of a straight flat line with a total one hundred millimeters long, and frequently it has 10 points in which the patients describes his/her own pain experience from the starting point of the line which represent (pain free or 0) or through the ending point of the line which represent (worst pain in which the patient can't tolerate or 10). (Bodian et al., 2001; Crichton, 2001; Carlsson, 1983)

3.6. Search strategy for identification of studies

Studies were retrieved from following database: EMBASE, PubMed, CINAHL, Medline, SpringerLink, ProQuest. The strategy of searching is done by using different integrations of the key words which are mentioned in the following subdivision.

3.7. Key words

Rotator cuff tendinopathy, Extracorporeal shockwave therapy, Arthroscopy, Shoulder calcification, tendinitis, surgical debridement, Radial shock waves, Rotator cuff, tendinosis, constant and murley score, therapy, visual analogue scale, focused shock waves.

3.8. Data extraction

The fundamental data of the reviewed studies were analyzed and summarized in an effort to allow simpler comparison and understanding of results by the readers and the reviewers. The extracted data included information about the studies' authors, publication year, goal and design of the study, participant properties (their number, age, diagnosis, and symptoms), type of interventions (control intervention were included if it used), outcome measures, results, and follow up. The full data extraction between the treatment groups information in the analytical form can be found in the tables below.

4. Results

A total of 114 studies were retrieved from the scientific databases which underwent a holistic reviewing process of each study. After the final review of the studies only 33 studies were found qualified to be included in this research (21 shockwave articles, and 12 surgical articles) depending on the research criteria, and the outcome measures (i.e. the constant and murley score (CMS), and the visual analogue scale (VAS).

The range of the articles dates that have been found to be qualified to this research are between 2000 and 2016. The total number of the participants of all studies were 2,124 patients (male and female) whether that patients were experimental or controlled. The approximated patients' ages were raged from 26 to 83 years of age, and diagnosed by chronic calcification tendinopathy of the rotator cuff. Moreover, in order for these patients to be applicable for the for trials they should be with at least 3 months' period of symptoms, and failure of other way of treatment. regarding the design of the studies 19 studies were randomized controlled trial (3 of them were surgical, and 17 are ESWT studies), 5 prospective studies, 5 retrospective studies (surgical), and 4 therapeutic case series studies (surgical). The types of therapy are variable; They used FESWT, RESWT in different energy levels (high, medium, low) in regarding the shockwave articles, and an arthroscopic debridement (removal) of the calcification of the rotator cuff, and/or acromioplasty) in regarding the surgical articles. The treatment duration in the ESWT studies was ranged from one session to eighteen sessions with interval time ranged from four days to two weeks, and the surgical treatment duration was not clarified in the articles.

4.1. Comparison tables

Table 1. ESWT articles review including participants' features, intervention types, studies design, characteristics of the involved groups, outcome measure.

Authors/Year	Participants	Age in years	Intervention	Study Design	Groups	Outcome Measures
Albert et al. (2007)	80	31-69	ESWT	Prospective single blind randomized trial	High energy ESWT **vs** Low energy ESWT	- CMS - VAS
Cacchio et al. (2006)	90	40–62	RESWT	Single Blind RCT	RESWT **vs** Control	- VAS
Charrin & Noël (2001)	32	49.8 ± 5.9	ESWT	Prospective open design study	ESWT under US guidance	- CMS - VAS

Cosentino et al. (2003)	70	35-68	ESWT	Single Blind RCT	ESWT **vs** Sham	- CMS
Daecke et al. (2002)	- One session=56 - Two session=59	28-77	ESWT	prospective study	One session high dose ESWT **vs** Two sessions high dose ESWT	- CMS
Del Castillo-González et al. (2016)	- ESWT=121 - UGPL=122	49±7	ESWT	Prospective RCT	ESWT **vs** UGPL	- VAS
Farr et al. (2011)	30	G1: 49.7±9.0 G2: 48.6±7.3	FESWT	Prospective Single Blind RCT	High dosage FESWT **vs** Low dosage FESWT	- CMS - VAS
Gerdesmeyer et al. (2003)	144	-High Energy ESWT group: 51.6 ±8.5 - Low Energy ESWT group: 47.3 ±8.5 - Sham group: 52.3 ±9.8	ESWT	Double blind randomized placebo Controlled trial	High Energy ESWT **vs** Low Energy ESWT **vs** Sham	- CMS - VAS

Haake et al. (2002)	50	29-68	ESWT	Prospective blinded trial with a randomized two sample parallel group design	ESWT focused at Calcific Deposit **vs** ESWT focused at Tuberculum Majus	- CMS
Hsu et al. (2008)	- ESWT=33 - Control=13	30-82	ESWT	Prospective RCT	ESWT **vs** Control (sham)	- CMS - VAS
Ioppolo et al. (2012)	46	29-78	ESWT	Single Blind RCT	ESWT with energy level of 0.10 mJ/mm^2 **vs** ESWT with energy level of 0.20 mJ/mm^2	- CMS - VAS
Kim & Kwak (2016)	- ESWT=20 - Control=25	40-65	ESWT	RCT	ESWT **vs** Control	- CMS

Kim et al. (2014)	- ESWT= 32 - US-needling= 30	45-78	ESWT	Prospective randomized trial	ESWT **vs** US guided needling	- VAS
Magosch et. al. (2003)	35	33-73	RESWT	Prospective study	Low energy RESWT	- CMS
Maier et. al. (2000)	62	33-64	ESWT	Prospective study	Low energy ESWT	- CMS
Pan et al. (2003)	- ESWT=32 - TENS=28	ESWT: 55.21±2.01 TENS: 58.00±1.83	ESWT	RCT	ESWT **vs** TENS	- CMS - VAS
Perlick et al. (2003)	80	38-64	ESWT	RCT	ESWT with EFD of ($0.23 mJ/mm^2$) **vs** ESWT with EFD of ($0.42 mJ/mm^2$)	- CMS
Pleiner et al. (2004)	- ESWT=23 - Control=20	G1: 54± 11 G2: 50±8	ESWT	Double Blinded RCT	ESWT with EFD ($0.28 mJ/mm^2$)**vs** Control	- CMS - VAS

Sabeti et al. (2007)	- ESWT=22 - EWST with local anesthesia=25	49.38±8.37	ESWT	prospective randomized observer blind study	ESWT **vs** ESWT with local anesthesia	- CMS - VAS
Sabeti-Aschraf et al. (2005)	50	G1: 52.86±8.19 G2: 52.4±7.74	F-ESWT	Prospective Single Blind RCT	Low energy FESWT **vs** Low energy FESWT with fluoroscopic focusing	- CMS - VAS
Wang et al. (2001)	29	36-66	ESWT	Prospective clinical study	ESWT	- CMS - VAS

Table 2. Arthroscopic articles review including participants' features, intervention types, studies design, characteristics of the involved groups, outcome measure.

Authors/Year	Participants	Age in years	Intervention	Study Design	Groups	Outcome Measures
Cadenas et al. (2010)	18	33-63	Arthroscopy	Retrospective study	Arthroscopic with acromioplasty and/or suturing	- CMS
Clement et al. (2015)	80	32-75	Arthroscopy	Prospective Randomized Controlled Trial	Patients with SAD **vs** without SAD	- CMS - VAS
El Rassi et al. (2016)	Resection= 31 Acromioplasty=50	33-81	Arthroscopy	Retrospective study	Resection of calcification **vs** acromioplasty	- CMS
Lorbach et al. (2008)	65	35-65	Arthroscopy	Retrospective study	Arthroscopic removal of the calcific deposit (only 1 group)	- CMS - VAS
Maier et al. (2013)	102	31-68	Arthroscopy	Prospective therapeutic case series	patients with complete CD removal **vs** patients showing minor RCs	- CMS
Maier et al. (2014)	82	32-68	Arthroscopy	Prospective Case series	ACDSSP without acromioplasty (only 1 group)	- CMS

Porcellini et al. (2004)	63	28-44	Arthroscopy	Retrospective study	According to deposit size group A: >10 mm **vs** group B: 10-20 mm **vs** group C: >20 mm	- CMS
Rubenthaler et al. (2003)	38	Mean: 51.1	Arthroscopy	Prospective Randomized	Endoscopic decompression **vs** open surgery	- CMS - VAS
Sabeti et al. (2014)	20	47.55±7.91	Arthroscopy	prospective randomized controlled and clinical observer blinded pilot trial	the deposit was localized conventionally **vs** the deposit was localized using intraoperative ultrasound	- CMS - VAS
Seil et al. (2006)	58	29-62	Arthroscopy	therapeutic case series	arthroscopic removal of rotator cuff calcifications (only one group)	- CMS
Seyahi & Demirhan (2009)	- Pure tendinous= 25 - tendinous and osseous=5	26-83	Arthroscopy	Therapeutic case series	Patients with pure tendinous **vs** patients with tendinous and osseous	- CMS - VAS
Yoo et al. (2010)	35	G1: 52.2 G2: 49.8	Arthroscopy	Retrospective study	calcific material removal **vs** side-to-side repair or simple debridement.	- CMS - VAS

4.2. Summarization of results

4.2.1. Extracorporeal shockwave therapy (ESWT) studies

Albert et al. (2007) in their Prospective single blinded randomized trial investigated the efficacy of the high energy, and low energy ESWT in the treatment of the rotator cuff calcification tendinopathy, the total of the participants for this trial were 80 subjects which are equally divided into two randomized into to equal groups the patient who included in this trial has at least a 3 months duration of the symptoms, and a calcification diameter of at least ten mm. the duration of the treatment was two sessions which separated by fourteen days' rest, each patient of the two groups received about two thousand five hundred impulses each session, the final follow up period was set up after 3 months after the treatment, both groups shows a significant improvement in the CMS, and VAS but the high energy group has more statistical significant that the other group.

According to **Cacchio et al. (2006)** in their Single Blinded RCT which compared the effectiveness of the RESWT and placebo (less effective same therapy) in treating calcification tendinitis of the rotator cuff, ninety participants were randomized into two equal groups, all participants has a history of failed previous conservative treatments, and a duration of the symptoms of at least six months. The total duration of the treatment for the two treatment groups was four sessions with a week interval, the treatment group received a two thousand five hundred impulses per session and EFD of (0.10 mJ/mm^2) while the placebo group received only twenty-five impulses per session. As for the result after one week of the treatment and, at six months follow up there was a significant statistical improvement of the VAS in the treatment group and not in the placebo group.

In the Prospective open design study performed by **Charrin & Noël (2001)** evaluate the efficacy of the ESWT under US guidance in the treatment of calcific rotator cuff tendinitis. The total population of the study were 32 participants; each patient has minimum 6 months' duration of symptoms. The duration of the treatment is 2 or 3 sessions with an interval of 13.4 ± 6.4 days, during the treatment each patent received a total of two thousand

impulses per session about for twenty to thirty minute. The used EFD (0.32 mJ/mm^2), as for the result the CMS showed a significant statistical improvement at twelve weeks after the treatment but not after the 24 weeks. And for the VAS there was a significant statistical improvement at the twelve and the twenty-four weeks after the treatment.

Cosentino et al. (2003) in their Single Blind RCT they have evaluated the effect of the ESWT in the treatment of chronic calcific tendinitis of the shoulder in comparison to sham treatment (simulated treatment), the total population number of the study were 70 subjects; which randomized equally into two groups, all patient has suffered from at least ten months' duration of the symptoms and failure of 6 months' other treatments. The total duration of the treatment for the two treatment groups was 4 treatment sessions with four to seven days' interval. Each patient in the two groups received a total of one thousand two hundred impulses per session; the treatment group had an EFD of (0.03-0.28 mJ/mm^2), while the simulated treatment group had an EFD of (0 mJ/mm^2), as for the result after the treatment, at one, and six months there was a significant increase in the CMS in the ESWT group in comparison to the simulated treatment.

Daecke et al. (2002) in their prospective study they have researches the efficacy of the high dose ESWT in treating chronic calcific tendinosis of the rotator cuff. The total population of the study were 115 participants; the first group had 56 participants, and the second group had 59 participants. All patient had least twelve months' duration of the symptoms and failure of six months' other type of treatments before the study. The first group had only one session and two thousand impulses of high dose ESWT, while the second group had two session of the same treatment with a week interval, with regards the result both groups show a significant increase in the CMS, but with no significant statistical difference between the result of the two group.

Del Castillo-González et al. (2016) in their prospective RCT which compared the effect of the ESWT and the ultrasound guided percutaneous lavage (UGPL) in treating rotator cuff calcific tendinitis, the total number of participants were 243 subjects; randomized into ESWT group which had 121 participants, and UGPL group which had 122

participants. The duration of the treatment for the ESWT was two sessions/week for 4 weeks in which the patients received two thousand impulses/session of EFD (0.20 J/mm^2), with regards the result both groups showed a significant decrease in the VAS after the treatment and at follow-ups but the result was more significant in the UPGL group.

In the Prospective Single Blind RCT study done by **Farr et al. (2011)** which compared the effect of High level and Low level FESWT in treating calcific tendinitis of the rotator cuff. The total population of the study were 30 patients divided into two equal groups, all patients had persisting symptoms for at least six months and failed 2 other treatment sessions. the 1st group had 1 session with EFD of (0.3 mJ/mm^2), while the 2nd group had 2 sessions with a week interval of EFD (0.2 mJ/mm^2), both groups showed a significant decrease in VAS and improvement of CMS without significant difference between the groups result.

Gerdesmeyer et al. (2003) in their Double blind randomized placebo Controlled trial which compared the effect of high, low level ESWT, and placebo in treating chronic calcific rotator cuff tendonitis. The total population of the study were 144 subjects which randomized equally into 3 groups. All patient had at minimum six months' duration of the symptoms and failure of other treatment types before the study. The duration of the treatment for all groups was two sessions with two weeks' interval. Patients in the high level group received one thousand five hundred shock waves of (0.32 mJ/mm2), while the low level group received six thousand shock waves of (0.08 mJ/mm2), and the sham group had the same procedure but with air room poly-ethylene coil was placed between the patient and the fluid cushion of the ESWT, for the result there was a significant increase in the CMS, and decrease in the VAS in the High level ESWT group compared to the other groups.

Haake et al. (2002) in the Prospective blinded trial with a randomized two sample parallel group design study which compared the effect of ESWT focused at Calcific Deposit and ESWT focused at Tuberculum Majus. The total population of the group was fifty participants which randomized equally into two groups. All patient had at minimum six months' symptoms duration and failure of other treatment types before the study. The

duration of the treatment was two sessions with a week interval in which all groups received two thousand impulses of (0.35 mJ/mm^2), except the shockwaves were aimed exactly at the calcific deposit in the second group while the first group aimed at the origin of the supraspinatus tendon, regarding the result both groups showed a significant improvement of the CMS but the second group showed more significant statistical improvement.

In the Prospective RCT of 46 subjects performed by **Hsu et al. (2008)** to evaluate the effect of ESWT in treating shoulder calcifying tendinitis compared to sham treatment. the total participants were randomized into ESWT group which had 33 patients and control 23 patients. Patients has at least three months of persisted symptoms and failure to other treatment methods. the duration of the treatment was two sessions with two weeks' interval. Both groups received one thousand impulses/session of (0.55 mJ/mm^2) except the control group had a dummy ESWT electrode, the result showed a significant statistical increase in CMS, and VAS in the ESWT and not in the control group.

In other study held by **Ioppolo et al. (2012)** to investigate the effect of the two energy levels of ESWT in treating supraspinatus calcifying tendinitis, they have enrolled a total of 46 participants which divided randomly into two groups equal in numbers. All patients had active symptoms for at least four months' duration. The treatment program was for a total of four sessions with a week interval. Both groups received a two thousand impulses/session. The first group had EFD (0.20 mJ/mm^2), while the second group had (0.10 mJ/mm^2) of EFD, the result showed a significant statistical improvement in the CMS, and VAS in the 1st group compared to the 2nd group.

Kim & Kwak (2016) in a RCT they have evaluated the functional outcomes after the application of ESWT compared control treatment in the condition of calcific tendinopathy of the shoulder. The total population of the study were 45 subjects which then randomized into ESWT group which had 20 participants, and control group which had 25 participants. both groups had non-steroidal anti-inflammatory drugs (NSAID) for six weeks, hot pack for twenty minutes, transcutaneous electrical nerve stimulation (TENS) for fifteen minutes, ultra-sonographic therapy for five minutes, three times weekly for twelve weeks.

Additionally, the ESWT group received two hundred forty impulses/minute per session with energy flux density (0.14 mJ/mm^2) for three sessions/week for total of six weeks, the result showed a significant statistical improving in the shoulder function and reduction of pain according the CMS in the ESWT group compared to the other group.

Kim et al. (2014) in their Prospective randomized trial that compared the effectiveness of the ESWT in comparison to US guided needling to treat calcifying tendinopathy of the shoulder. all the participants who included in this study had at least three months' duration of active symptoms. the number of the participants in this study were 63 subjects which randomized into ESWT group (32), US needling group (30). The ESWT group received one thousand impulses of (0.36 mJ/mm^2) for one session/ week for 3 weeks' duration, while the Us needling group had subacromial corticosteroid injection. As for the result there was a significant statistical decrease in the VAS in both groups but after a year follow up the result was more significant in the US needling group.

In other prospective study performed by **Magosch et. al. (2003)** which they have investigated the effectiveness of the low energy RESWT in the treatment of calcific tendinopathy of the rotator cuff. The total population of the study were 35 patients, and all of them had a minimum duration of active symptoms of six months. Each session all patients had two thousand shockwave impulses of (0.12 mJ/mm^2) energy flux density, in total of 3 sessions with seven to ten days' intervals. Regarding the result there was a significant statistical improvement in the CMS after the treatment and at all follow-up.

In second similar study that carried out by **Maier et. al. (2000)** in which they have evaluated the effect of the low energy ESWT in the treatment of calcific tendinopathy of the shoulder. Total study sample were 62 participants, all of them had at least six months' active symptoms duration. The duration of the treatment was one session/week for four weeks, in which each patient received two thousand impulses/ session. With regarding the result there was a significant statistical increase in the CMS after the treatment and at all follow-ups.

Furthermore, in the RCT performed by **Pan et al. (2003)** which compared the efficacy of the ESWT and TENS to treat chronic calcifying tendinopathy of the shoulder. With a total number of participants of 60 subjects randomized into ESWT group which had 32 patients, and TENS group which had 28 patients. All patients had history of continues pain for at least 6 months. ESWT group received two thousand shockwave impulses with EFD of (26-32mJ/mm^2) per session for two sessions interrupted by fourteen days, in the other hand the duration of the treatment of the TENS was three sessions/week for four weeks, in which they had a frequency of 95 Hertz (Hz) and each session lasted about twenty minute. in regarding the result there was a significant statistical improvement in the values of the CMS, and the VAS in the ESWT in comparison to the TENS group at two, four, and twelve weeks' follow-up.

Other RCT performed by **Perlick et al. (2003)** to investigate the efficacy of the ESWT in the treatment of the calcification tendinitis of the rotator cuff. the overall population of the study were 80 subjects that randomized into two groups equal in numbers, all participants of this study had at least twelve months of active symptoms. duration of the treatment was 2 sessions with three weeks between them, in which both groups received a total of two thousand shockwave impulses/session, but the difference was that the first group had EFD (0.23mJ/mm^2), and the second group had EFD (0.42mJ/mm^2), finally the result at follow-ups showed significant improvement in the CMS in both group but the result was higher in the second group.

In second similar Double Blinded RCT done by **Pleiner et al. (2004)** in which they have evaluate the effectiveness of the ESWT compared to control treatment in the treatment of calcifying tendinopathy of the shoulder. The total population of the study were 43 participants randomized into ESWT treatment group which had about 23 patients, and control group which had 20 participants. All participants had chronic shoulder pain for at least six months. Duration of the treatment for both groups was 2 sessions with 2 weeks' interval, in which each patient of both groups received two thousand shockwave impulses/session, the treatment group had EFD (0.28 mJ/mm^2), and the control group had EFD (more than 0.07 mJ/mm^2) and foam membrane to decrease the shockwave energy that

reaches the shoulders. Regarding the result in the treatment group there was a significant statistical improvement in the CMS at all follow-ups compared to the control group.

Sabeti et al. (2007) in their prospective randomized observer blind study evaluated the effectiveness of ESWT in the treatment of the calcifying tendinitis. The total population of the study were 47 participants which randomized into ESWT group which had 22 subjects, and ESWT with local anesthesia which had 25 subjects. All patients had at least 2 failure other methods treatments and 6 months' duration of the symptoms. the first group had a total of three sessions with week interval in which they had one thousand impulses/session of (0.08 mJ/mm^2), and the second group had two sessions with a week interval in which they had two thousand impulses/session of (0.2 mJ/mm^2). The result showed that both group showed a significant improvement in the CMS, and the VAS but there were no significant statistical differences between the result of the 2^{nd} groups.

Sabeti-Aschraf et al. (2005) in their Prospective Single Blind RCT that evaluate the effect of the FESWT in the treatment of calcifying tendinitis of the shoulder. The total population the study were 50 participants randomized into 2 groups equals in numbers, all participants had at least six months' symptoms periods and 2 failed other types of treatment. both groups received one thousand impulses/session of (0.8 mJ/mm^2) for a total of three sessions with a week interval, the difference was that the application of the shockwave in second group was determined by radiographs and the first group by the therapist. Regarding the result there was a significant statistical improvement in the CMS, and the VAS in both group, but the 2^{nd} group has an advantage in their result compared to the first one.

Wang et al. (2001) in their Prospective clinical study that investigated the effectiveness of the ESWT in the treatment of the calcific tendinitis of the rotator cuff muscles. The total participation of the study were 29 subjects. All participants had a minimum of 6 months' other conservative treatments. each patient received one thousand shockwave impulses/session of (0.18 mJ/mm^2) for one session only, while 10 patients had a second session after thirty to sixty days from the first session. As for the result there was a significant statistical improvement in the CMS, And the VAS after the treatment

4.2.2. Surgical (Arthroscopic) studies

Cadenas et al. (2010) in their retrospective study which investigates the efficacy of the Arthroscopic acromioplasty and/or suturing of calcific tendinopathy of the shoulder. The total population of the study were 18 participants, in which all of them had at least six months' symptoms duration and had a conservative therapy before the study by of four months. The Arthroscopic procedure was performed in the (deck chair) position in 13 patients or side lying position in 5 patients. In addition, a liner traction was applied according to the weight of each patient. The result showed a significant statistical improvement in the CMS after the procedure.

In a Prospective Randomized Controlled Trial done by **Clement et al. (2015)** to investigate the short term outcomes of arthroscopic buresectomy debridement with or without subacromial decompression (SAD) in the condition of the calcific rotator cuff tendinopathy. They were able to recruit a total of 80 participants in their study which randomized equally into 2 groups. all participants had the surgical procedure under general anesthesia in addition to ultrasound-guided inter scalene blockage; the procedure was done in the (beach chair) position and A 5.5 millimeters shaver was used to remove the calcification. Regarding the result at year follow up there was a significant improvement in the CMS, and the VAS in both groups, however there was no statistical difference of the result between the groups.

El Rassi et al. (2016) in their retrospective study which evaluated the functional outcomes of the arthroscopic resection in the treatment of non-homogenous calcifying tendinitis of the rotator cuff. A total of 81 subjects was enrolled in this study, and divided into resection of calcification group had 31 patients. And the acromioplasty had 50 patients. The surgical procedure was performed in the beach chair position, using a 4.5 millimeters (30º) arthropod. The result showed that after the treatment both groups has a significant statistical improvement in the CMS, but the improvement was higher in the acromioplasty group.

Lorbach et al. (2008) in their retrospective study which investigate the clinical outcomes of the arthroscopic removal of the calcific deposit in the condition of calcifying tendonitis of the shoulder. Total population of the study were 65 subjects, all participants had failure of ESWT treatment before the operation. The surgical procedure was performed in the (bench chair) position under general anesthesia, in addition a 5.5 millimeters synovial shaver was used to remove the calcification. As for the result at follow up there was a statistical improvement in the CMS and the VAS.

Maier et al. (2013) in their Prospective therapeutic case series which investigated the effect of arthroscopic treatment of the calcifying Tendinopathy of the rotator cuff. Their total participants were 102 participants divided into 2 groups according to the amount of calcific deposit (CD) removal that achieved. the first group includes patients with complete CD removal and the second group includes patients showing fewer residual calcifications. The procedure was done in the lateral decubitus position under general anesthesia. As for the result There was no statistical difference in the overall CMS between the groups.

In other Prospective Case series made by **Maier et al. (2014)** to evaluate the effectiveness of the arthroscopic removal of chronic symptomatic calcifications of the supraspinatus tendon. Total population of the study were 82 participants. All patients had at minimum six months of conservative therapy before the surgery, and all of them had pain in the resting positions. The surgical procedure is performed in lateral decubitus position under general anesthesia, using a shaver to perform the bursectomy. For the result the overall CMS showed no statistical difference after the procedure. however, abduction was significantly lower in patients with type three compared with type one and type two calcification, also it was lower in patients who had longer symptoms duration.

Porcellini et al. (2004) in a retrospective study made to investigate the clinical and ultra-sonographic outcomes of the arthroscopic treatment of calcifying tendinitis of the rotator cuff. The total evaluated population in this study were 63 participants, the patient who included in this study had calcification type one (<10 millimeters), two (10–20 millimeters), and three (>20 millimeters) on radiographic examination. The procedure was

performed in lateral decubitus position with traction of five kg applied to targeted arm under general anesthesia and scalene blocker, the removal of calcific deposit is done by the use of a Linvatec 4.2 millimeters full radius shaver. For the result at twenty-four months' follow-up there was a significant statistical improvement in the CMS in all group without a significant difference between them.

Rubenthaler et al. (2003) in their prospective randomized study which evaluate the clinical and functional outcomes of the surgical treatments for calcification tendinopathy. They recruited a total of 38 participants randomized into endoscopic decompression group which had 19 patients, and open surgery group which had 19 patients. The result at follow-up showed no significant difference in regards to the CMS, and the VAS between the two groups.

Sabeti et al. (2014) In second prospective randomized controlled and clinical observer-blinded pilot trial which evaluate the effectiveness of arthroscopic debridement of calcific rotator cuff tendinopathy. The total population of the study were 20 randomized into 2 groups equal in number in which the 1st group the deposit was localized conventionally, and the 2nd group had the deposit localized using intraoperative ultrasound. All procedures were performed in beach chair position without using a shaver. Regarding the result at two, six weeks, and nine months both groups showed a significant improvement in the CMS, and the VAS but without a significant different between them.

Seil et al. (2006) in a therapeutic case series that reviewed the effectiveness of the arthroscopic removal of supraspinatus calcifying Tendinopathy. The number of patients was (n=58) the patients who included in this study has a calcification type one, and two according to the French arthroscopic society and all of them had a conservative treatment before the surgery by nine months. the procedure started with a five to ten millimeters longitudinal incision parallel to the direction of the muscle fibers, and the calcification was removed by an unsharpened instrument, and a shaver was used only in the cases that had a high density deposits, the result showed a significant statistical improvement in the CMS after twenty-four months' follow-up.

Furthermore, in other a therapeutic case series done by **Seyahi & Demirhan (2009)** to review the clinical outcomes of the arthroscopic removal of the intraosseous deposits in calcifying tendinopathy of the rotator cuff. Total population of the study were 28 participants divided into patients with pure tendinous involvement group which includes 25 patients, and patients with tendinous and osseous involvement group includes 3 patients. All patients had at least three months' conservative treatment before the procedure. The arthroscopic procedure is done in the (beach chair) position under general anesthesia using a twenty-gauge spinal needle to identify the calcific deposit. The result showed a significant statistical improvement in the CMS, and the VAS after the procedure in both groups, but there were no differences in the result between the 2 groups.

Yoo et al. (2010) in their retrospective study which investigate the efficacy of the arthroscopic treatment of chronic calcification tendinopathy. The total number of participants in this study were 35 patients divided into group that had calcific material removal which includes 18 patients, and the second group had side-to-side repair or simple debridement which includes 17 patients. All patients had at least 6 months' failure conservative treatment before the operation. They used a spinal needle to identify the calcific deposits. Regarding the result also there was a significant statistical improvement in the CMS, and the VAS after the procedure in both groups, but there was no significant difference between the result of the 2 groups.

5. Discussion

5.1. Discussion of the research questions

After the analyzation of the result, we found that almost all of the 21 studies that were included in this research which used the ESWT (regarding its' type, and the energy level which used) as their main intervention device to investigate its effectiveness in treating the condition of chronic calcific rotator cuff tendinopathy has manifested a good result after the treatment and at the follow-ups in regarding the CMS, indicating a high efficacy level of the ESWT in improving and maintaining the proper shoulder function, also almost all of the studies showed a significant improvement result regarding the VAS, which also indicates a high effectiveness of the ESWT in reducing the pain experienced by the patients.

Moreover, 9 out of 12 articles (that used the arthroscopic as the main treatment procedure to treat the condition of chronic calcific rotator cuff tendinopathy have suggested a significant improvement in the result after the application of the arthroscopic treatment in regarding the CMS, and the VAS. While 3 articles didn't support the effectiveness of the surgical treatment in the outcome measures that used in their studies.

On the other hand, in order to answer the research questions, we need to discuss the scientific level of the evidence of the articles which will also give us an important information that will help us define which of the two intervention (ESWT, arthroscopy) is more effective regarding the research questions. So, for the EAWT all of the studies that found has a strong scientific evidence level by that we mean (randomized control trials, and prospective studies), while for the arthroscopy the majority of the articles found has a weak scientific level of evidence and by that we mean (retrospective studies, and therapeutic case series studies).

Another very important information we took in count in order to answer the research question is that ESWT in is considered non-invasive therapeutic procedure, and also it doesn't require the patients to go under general anesthesia; However, in some cases it may

cause a discomfort feeling during the application. While the arthroscopy is considered as an invasive procedure and requires the patients some times to be under general anesthesia during the procedure.

Eventually, due to the poor evidence of that support the effectiveness of the arthroscopic intervention in treating chronic calcific rotator cuff tendinopathy, and the lack of the articles that is done on this condition, and considering that it is an invasive procedure and done under general anesthesia, it is not recommended to be the first line of treatment for the patients with chronic calcific rotator cuff tendinopathy, on the opposite side the ESWT has a strong level of evidence and a good result indicating that ESWT may has an advance over the arthroscopy in the reduction of the pain and improving the shoulder functions of the chronic calcific rotator cuff tendinopathy. So it is recommended to start the treatment with the ESWT, and in case of the presence of a large calcifications and frailer of the ESWT treatment, in that case the patients shall be advised to seek for the arthroscopic procedures.

5.2. Discussion of intervention types

5.2.1. Extracorporeal shockwave therapy (ESWT) intervention

One of the used shockwave devices in the trial that we recruited in this research is the radial extracorporeal shockwave therapy (RESWT) which is used in several studies that we recruited in this research including a study performed by Cacchio et al. (2006), and another study made by Magosch et. al. (2003). The other shockwave device that used by the trials is the focused extracorporeal shockwave therapy (FESWT) which is used by Farr et al. (2011), and Sabeti-Aschraf et al. (2005). While the rest of articles have not identified the type of the ESWT that are used in their trials.

As for the energy flux density (EFD) of the ESWT unit it was varied from one trial to another; some of the authors used low EFD (0.01- 0.14 mJ/mm^2) in their studies (Cacchio et al., 2006; Farr et al., 2011; Gerdesmeyer et al., 2003; Ioppolo et al., 2012; Kim & Kwak, 2016; Magosch et. al., 2003; Sabeti et al., 2007; Sabeti-Aschraf et al., 2005). While other

studies used medium EFD (0.14-0.32 mJ/mm^2) in their studies (Charrin & Noël, 2001; Cosentino et al., 2003; Del Castillo-González et al., 2016; Ioppolo et al., 2012; Pan et al., 2003; Perlick et al., 2003; Pleiner et al., 2004; Wang et al., 2001). Lastly, some studies used high EFD (more than 0.32 mJ/mm^2) in their trials such (Haake et al., 2002; Hsu et al., 2008; Kim et al., 2014; Perlick et al., 2003). However, there was no preferences in the results regarding the type and the EFD of the ESWT that used all of the interventions showed a significant improvement in the CMS and the VAS after the application.

5.2.2. Surgical intervention

Usually the surgical intervention in the case of chronic calcific tendinopathy of the rotator cuff is the arthroscopic procedure which can be done in different positions, with/or without general anesthesia, and sometimes it can be combined with different procedures such as (acrimioplasty); while in some articles they compare the arthroscopic treatment with open surgery (Rubenthaler et al., 2003).

Arthroscopic treatment in some articles is performed in a different methods sub-acromial decompression (SAD) method (Clement et al., 2015; Rubenthaler et al., 2003), resection of the calcification method (Clement et al., 2015; El Rassi et al., 2016; Lorbach et al., 2008; Maier et al., 2013; Maier et al., 2014; Porcellini et al., 2004; Seil et al., 2006; Seyahi & Demirhan, 2009; Yoo et al., 2010), and debridement of the calcification method (Sabeti et al., 2014; Yoo et al., 2010), and the acromioplasty method (Cadenas et al., 2010; El Rassi et al., 2016). However, the resection of the calcification method had shown the weakest effectiveness in the treatment of the chronic calcification tendinopathy according to two authors (Maier et al., 2013; Maier et al., 2014), while the rest of the arthroscopic methods.

Regarding the position of the operation some authors prefer the (deck-chair) position (Cadenas et al., 2010), the (beach chair) position (Clement et al., 2015; El Rassi et al., 2016; Lorbach et al., 2008; Sabeti et al., 2014; Seyahi & Demirhan, 2009), and the “lateral decubitus” position (Maier et al., 2013; Maier et al., 2014; Porcellini et al., 2004), which left

to the surgeon to decided which position is suitable for the operation according to the patient condition and the method that used to approach the shoulder by the arthroscopy, and it has no difference regarding the outcome result.

Furthermore, some authors prefer to perform the arthroscopic procedure under general anesthesia (Clement et al., 2015; Lorbach et al., 2008; Maier et al., 2013; Maier et al., 2014; Porcellini et al., 2004; Seyahi & Demirhan, 2009), and a liner traction to fixate the patients arm (Cadenas et al., 2010; Porcellini et al., 2004). Moreover, to remove the calcification authors used motorized shaver which is the most commonly used device (Clement et al., 2015; Lorbach et al., 2008; Maier et al., 2014; Seil et al., 2006), a 4.5mm (30 degree) arthropod (El Rassi et al., 2016), Linvatec 4.2-mm full-radius shaver (Porcellini et al., 2004), and Blunt instruments (Seil et al., 2006). There was no significant difference regarding which method is more effective than the others, but it eft to the surgeon to determine which method to be used in the surgical procedure according to the calcification size.

5.3. Discussion of the treatment duration

According to the treatment duration as mentioned above in the result section that different treatment duration has been used in ESWT like One sessions (Daecke et al., 2002; Farr et al., 2011; Wang et al., 2001), Two sessions (Albert et al., 2007; Charrin & Noël, 2001; Daecke et al., 2002; Farr et al., 2011; Gerdesmeyer et al., 2003; Haake et al., 2002; Hsu et al., 2008; Pan et al., 2003; Perlick et al., 2003; Pleiner et al., 2004; Sabeti et al., 2007; Wang et al., 2001), Three sessions (Charrin & Noël, 2001; Kim et al., 2014; Magosch et. al., 2003; Sabeti et al., 2007; Sabeti-Aschraf et al., 2005), Four sessions (Cacchio et al., 2006; Cosentino et al., 2003; Ioppolo et al., 2012; Maier et. al., 2000), Eight sessions (Del Castillo-González et al., 2016), and Eighteen sessions (Kim & Kwak, 2016). The number of sessions is shown to have no significant influence in regarding the outcomes result.

The intervals between the sessions was varied also from one week (Cacchio et al., 2006; Cosentino et al., 2003; Daecke et al., 2002; Del Castillo-González et al., 2016; Farr et

al., 2011; Haake et al., 2002; Ioppolo et al., 2012; Kim et al., 2014; Magosch et. al., 2003; Maier et. al., 2000; Sabeti et al., 2007; Sabeti-Aschraf et al., 2005), Two weeks (Albert et al., 2007; Gerdesmeyer et al., 2003; Hsu et al., 2008; Pan et al., 2003; Pleiner et al., 2004), and up to Three weeks. (Perlick et al., 2003) it was found that the studies that had a one-week interval between the sessions has a little improvement of the result regarding the pain compared to the studies that induces a longer interval times between the sessions.

As for arthroscopy there the treatment duration was not clear in the articles, and it can be varied from one author to another.

5.4. Discussion of the long term effect of both interventions

For the ESWT studies the improvement of the CMS, and the VAS was continuing after the three months (Albert et al., 2007; Kim & Kwak, 2016), Six months (Cacchio et al., 2006; Charrin & Noël, 2001; Cosentino et al., 2003; Pan et al., 2003), Seven months (Pleiner et al., 2004), Eight months (Maier et. al., 2000), One year (Del Castillo-González et al., 2016; Gerdesmeyer et al., 2003; Haake et al., 2002; Hsu et al., 2008; Ioppolo et al., 2012; Kim et al., 2014; Magosch et. al., 2003; Perlick et al., 2003), and Four years (Daecke et al., 2002) follow-ups. Which indicates that the ESWT has a prolonged effect on the pain and the shoulder function by maintaining the result of reduced pain, and improved shoulder functions for longer time (in some scenarios up to four years) as mentioned above, thus ESWT is considered to be very effective on the long term treatment plans.

However, the arthroscopic studies recorded the effectiveness of their result on Six months (Cadenas et al., 2010), Eight months (Maier et al., 2014), Nine months (Lorbach et al., 2008; Maier et al., 2013), One year (Clement et al., 2015), Two years (El Rassi et al., 2016; Seil et al., 2006; Porcellini et al., 2004), and Three years (Seyahi & Demirhan, 2009). This also may suggest that also the arthroscopic intervention may also have a good result on the long term (up to four years). On the other hand, most of the articles that support this opinion are from the low scientific evidence thus, we think that the ESWT has proven

scientifically to have a long term effect on reducing the pain, and improving the shoulder function that associated with chronic calcific rotator cuff tendinopathy.

5.5. Discussion of other studies

There are different other strong evidence studies that has used the ESWT in treating other musculoskeletal conditions, or used it on the animals' subjects which will be discussed in the following section.

There are a quite number of studies that has investigated the effectiveness of the ESWT to treat the condition of planter fasciitis, Achilles tendinopathy, and iliotibial band syndrome. A randomized placebo controlled trial performed by Saxena et al. (2012) to the effect of ESWT, sham ESWT, and endoscopic plantar fasciotomy to treat chronic heel pain in sportsmen society, they found that ESWT is effective and recommended to treat this condition due to that the sportsmen can compete with its application. Other Prospective Randomized Study done by Lohrer et al. (2010) to compare the effect of FESWT and RESWT to treat plantar fasciitis, they have concluded that both FESWT and RESWT are effective in treatment of planter fasciitis with a superiority of the FESWT. Similar Randomized Placebo-Controlled Multicenter Study by Gerdesmeyer et al. (2008) in which they used also RESWT to treat chronic recurrent plantar fasciitis, and they suggested that the RESWT is significantly approved to reduce the pain that is associated with chronic recurrent plantar fasciitis and improves the quality of the patients' life. Kudo et al. (2006) in a similar randomized placebo controlled double blind clinical trial treating plantar fasciitis with ESWT in which they have stated that the ESWT is non-invasive and effective in the treatment of plantar fasciitis.

According the use of ESWT in Achilles tendinopathy a prospective randomized clinical trial by Notarnicola et al. (2012) that used the ESWT with arginine to treat Achilles tendinopathy, their result showed that the shockwave therapy has positive effect in the treatment of Achilles tendinopathy. While for the iliotibial band syndrome a RCT by Weckström & Söderström (2016) was used to identify the effectiveness of the RESWT in

the treatment of the iliotibial band syndrome in which they found that the REWST showed significant decrease in the pain that felt by iliotibial band syndrome patient.

Other studies used the ESWT in treating adhesive capsulitis, and lateral epicondylitis. A RCT performed by Vahdatpour et al. (2014) to evaluate the functional outcomes of the ESWT in the treatment of the condition of the adhesive capsulitis, as their result showed that ESWT has significant effect in improving the functional outcomes, and the ADL for adhesive capsulitis patients. Other prospective randomized controlled single blind clinical trial by Chen et al. (2014) to treat the condition of adhesive capsulitis of the shoulder using ESWT, and they have suggested that for the short term period the ESWT can be a useful to improve the limitations of the ROM and the ADL of these kind of patient. As for the lateral epicondylitis of the elbow a double blind randomized controlled trial carried by Speed et al. (2002) with a purpose of evaluating the effect of ESWT on the lateral epicondylitis patients, and they stated that that the ESWT may have a positive effect on this condition compared to the false treatment but it not clear.

Other categories of studies were conducting the use of the ESWT on animal, as in a retrospective study made by Leeman et al. (2016) determined to investigate the effect of the application of the ESWT on the supraspinatus and biceps tendinitis on a twenty-nine doges, regarding their result they have suggested that the ESWT is considered to be a safe substation method to treat these kind of tendinopathies. Other similar study designed by Becker et al. (2015) on a fifteen dogs that diagnosed with shoulder Limping, they found that the ESWT showed a positive and promising result in improving the functions of the participated group. Other study performed using ESWT by Maier et al. (2001) on turkeys with gastrocnemius calcification tendinopathy, in which their result showed that the application of the ESWT has a promising result in decreasing the tendon calcification. In addition, an experimental study by Mackert et al. (2017) performed on a rat model with osteoporotic fracture the intervention used was low energy ESWT, their result revealed a significant improvement in the fracture healing. Moreover, another experimental study used ESWT performed by Wang et al. (2003b) on a rabbit subjects with Achilles tendinopathy in which they have found that

the application of the ESWT stimulates the neo-vascularization process in a way that could fasten the healing process of the injured tendons.

On the other hand, there are a few studies that used that arthroscopy as the main intervention or compared to other to investigate its efficacy to treat other tendinopathies such as patellar tendinopathy. A retrospective observational study made by Santander et al. (2012) which evaluated the effect of the arthroscopic treatment of chronic jumper's knee condition, their result induced that the arthroscopic treatment may reduce the pain felt by these patient and may also improves the function of the knee joint. Lastly, a RCT study performed by Willberg et al. (2011) to compare the effect of the sclerosing polidocanol injections and arthroscopic treatment to treat patients with patellar tendinopathy, they found that arthroscopic treatment may have an advantage over the sclerosing polidocanol injections in reducing the pain of that can be felt by the patellar tendinopathy patients.

5.5. Discussion of the limitations of this study

In this literature review there has been a few limitations which in some way affected the overall comparison between the two treatment intervention. There might be a potential risk of bias presented within this study in the arthroscopic studies due to the retrospective nature of the most arthroscopic studies, and also for the extracorporeal shockwave because in some of the trials there was no blinding option of the treatment information between the participants and the therapists. Moreover, regarding the arthroscopic articles there was a lack of strong evidence, and also there were some beneficial studies that does not have an English version or were not provided in the major academic resources or it can't be retrieved due to the expensive subscription fees.

6. Conclusion

This systemic review was established with a define purpose to investigate which methods between the ESWT and the surgical approach is more eligible and more effective in treating chronic calcific rotator cuff tendinopathy to be more specific, which is considered one of the most common painful pathologies that affect the shoulders which makes the patients that affected by it suffers from severe pain and overall reduction of the shoulder function.

In order to achieve this purpose a profound searching for a strong scientific evidence for both intervention methods, specific criteria, research questions and outcome measures were recruited in this study in order to make the proper suggestion on which method are effective. However, after the collecting and analyzing of the result there was a strong evidence that supports the effectiveness of the ESWT in treating not only chronic calcific rotator cuff tendinopathy, but also there was a promising result in treating other tendon pathologies in human subjects and also in animal subjects regarding the reduction of the pain and improving the loss of the shoulder function.

Moreover, there was evidence that supports the effectiveness of the surgical approach represented in the arthroscopic intervention in treating chronic calcific rotator cuff tendinopathy ant other tendon pathologies, but these evidence that found this effect are from the low level evidence. Thus, as a conclusion patient with rotator cuff tendinopathy may seek the ESWT as their first option for treatment because it is considered less invasive and easy to apply treatment method compared to the surgical approach, and seeks the arthroscopic approach in case of failure of the ESWT treatment.

7. Bibliography

1. Abate, M., Di Carlo, L., Salini, V., & Schiavone, C. (2017). Risk factors associated to bilateral rotator cuff tears. *Orthopaedics & Traumatology: Surgery & Research*, *103*(6), 841-845. DOI: 10.1016/j.otsr.2017.03.027
2. Albert, J. D., Meadeb, J., Guggenbuhl, P., Marin, F., Benkalfate, T., Thomazeau, H., & Chalès, G. (2007). High-energy extracorporeal shock-wave therapy for calcifying tendinitis of the rotator cuff: a randomised trial. *The Journal of bone and joint surgery. British volume*, *89*(3), 335-341. DOI: 10.1302/0301-620X.89B3.18249
3. Alford, J. W. (2008). Taking a closer look at rotator cuff disorders. *Journal of Musculoskeletal Medicine*, *25* (10), 481-488.
4. Andres, B. M., & Murrell, G. A. (2008). Treatment of tendinopathy: what works, what does not, and what is on the horizon. *Clinical Orthopaedics and Related Research*, *466*(7), 1539-1554. DOI: 10.1007/s11999-008-0260-1
5. Baumgarten, K. M., Gerlach, D., Galatz, L. M., Teefey, S. A., Middleton, W. D., Ditsios, K., & Yamaguchi, K. (2010). Cigarette Smoking Increases the Risk for Rotator Cuff Tears. *Clinical Orthopaedics and Related Research*, *468*(6), 1534-1541. DOI: 10.1007/s11999-009-0781-2
6. Becker, W., Kowaleski, M. P., McCarthy, R. J., & Blake, C. A. (2015). Extracorporeal shockwave therapy for shoulder lameness in dogs. *Journal of the American Animal Hospital Association*, *51*(1), 15-19. DOI: 10.5326/JAAHA-MS-6175
7. Bodian, C. A., Freedman, G., Hossain, S., Eisenkraft, J. B., & Beilin, Y. (2001). The visual analog scale for pain clinical significance in postoperative patients. *Anesthesiology: The Journal of the American Society of Anesthesiologists*, *95*(6), 1356-1361.
8. Bodin, J., Ha, C., Chastang, J. F., Descatha, A., Leclerc, A., Goldberg, M., ... & Roquelaure, Y. (2012a). Comparison of risk factors for shoulder pain and rotator cuff syndrome in the working population. *American Journal of Industrial Medicine*, *55*(7), 605-615. DOI: 10.1002/ajim.22002

9. Bodin, J., Ha, C., Sérazin, C., Descatha, A., Leclerc, A., Goldberg, M., & Roquelaure, Y. (2012b). Risk factors for incidence of rotator cuff syndrome in a large working population. *Scandinavian Journal of Work, Environment & Health*, *38*(5), 436-446. DOI: 10.5271/sjweh.3285
10. Boudreault, J., Desmeules, F., Roy, J. S., Dionne, C., Frémont, P., & MacDermid, J. C. (2014). The efficacy of oral non-steroidal anti-inflammatory drugs for rotator cuff tendinopathy: A systematic review and meta-analysis, *Journal of Rehabilitation Medicine*, *46*(4), 294-306. DOI: 10.2340/16501977-1800
11. Cacchio, A., Paoloni, M., Barile, A., Don, R., de Paulis, F., Calvisi, V., ... & Spacca, G. (2006). Effectiveness of radial shock-wave therapy for calcific tendinitis of the shoulder: Single-blind, randomized clinical study. *Physical therapy*, *86*(5), 672-682. DOI: 10.1093/ptj/86.5.672
12. Cadenas, J. B., Rodríguez, A. C., & García-Prendes, V. V. (2010). Rotator cuff calcifying tendonitis: Results of arthroscopic treatment. *Revista Española de Cirugía Ortopédica y Traumatología (English edition)*, *54*(2), 100-105. DOI: 10.1016/S1988-8856(10)70217-0
13. Camargo, P. R., Alburquerque-Sendín, F., & Salvini, T. F. (2014). Eccentric training as a new approach for rotator cuff tendinopathy: review and perspectives. *World Journal of Orthopedics*, *5*(5), 634-644. DOI: 10.5312/wjo.v5.i5.634
14. Carbone, S., Gumina, S., Arceri, V., Campagna, V., Fagnani, C., & Postacchini, F. (2012). The impact of preoperative smoking habit on rotator cuff tear: cigarette smoking influences rotator cuff tear sizes. *Journal of Shoulder and Elbow Surgery*, *21*(1), 56-60. DOI: 10.1016/j.jse.2011.01.039
15. Carlsson, A. M. (1983). Assessment of chronic pain. I. Aspects of the reliability and validity of the visual analogue scale. *Pain*, *16*(1), 87-101. DOI: 10.1016/0304-3959(83)90088-X
16. Charrin, J. E., & Noël, E. R. (2001). Shockwave therapy under ultrasonographic guidance in rotator cuff calcific tendinitis. *Joint Bone Spine*, *68*(3), 241-244. DOI: 10.1016/S1297-319X(01)00266-4
17. Chen, C. Y., Hu, C. C., Weng, P. W., Huang, Y. M., Chiang, C. J., Chen, C. H., ... & Cheng, C. K. (2014). Extracorporeal shockwave therapy improves short-term

functional outcomes of shoulder adhesive capsulitis. *Journal of Shoulder and Elbow Surgery*, *23*(12), 1843-1851. DOI: 10.1016/j.jse.2014.08.010

18. Chiou, H. J., Chou, Y. H., Wu, J. J., Hsu, C. C., Huang, D. Y., & Chang, C. Y. (2002). Evaluation of the calcific tendonitis of the rotator cuff: Role of color Doppler ultrasonography. *Journal of Ultrasound in Medicine*, *21* (3), 289-295. DOI: 10.7863/jum.2002.21.3.289
19. Choo, A., McCarthy, M., Pichika, R., Sato, E. J., Lieber, R. L., Schenk, S., ... & Ward, S. R. (2014). Muscle gene expression patterns in human rotator cuff pathology. *The Journal of Bone and Joint Surgery. American volume*, *96*(18), 1558-1565. DOI: 10.2106/JBJS.M.01585
20. Chung, B., & Wiley, J. P. (2002). Extracorporeal shockwave therapy. *Sports Medicine*, *32*(13), 851-865. DOI: 10.2165/00007256-200232130-00004
21. Clement, N. D., Watts, A. C., Phillips, C., & McBirnie, J. M. (2015). Short-Term Outcome After Arthroscopic Bursectomy Debridement of Rotator Cuff Calcific Tendonopathy With and Without Subacromial Decompression: A Prospective Randomized Controlled Trial. *Arthroscopy: The Journal of Arthroscopic & Related Surgery*, *31*(9), 1680-1687. DOI: 10.1016/j.arthro.2015.05.015
22. Cleveland, R. O., & McAteer, J. A. (2012). Physics of Shock-Wave Lithotripsy. *Smith's Textbook of Endourology, Volume I&II, 3rd Edition*, 527-558. DOI: 10.1002/9781444345148.ch49
23. Cleveland, R. O., & McAteer, J. A. (2012). Physics of Shock-Wave Lithotripsy. *Smith's Textbook of Endourology*, 527-558. DOI: 10.1002/9781444345148.ch49
24. Constant, C. R., & Murley, A. G. (1987). A Clinical Method of Functional Assessment of the Shoulder. *Clinical Orthopaedics and Related Research*, *214*, 160-164.
25. Cosentino, R., De Stefano, R., Selvi, E., Frati, E., Manca, S., Frediani, B., & Marcolongo, R. (2003). Extracorporeal shock wave therapy for chronic calcific tendinitis of the shoulder: single blind study. *Annals of the Rheumatic Diseases*, *62*(3), 248-250. DOI: 10.1136/ard.62.3.248

26. Crichton, N. (2001). Information Point: Visual Analogue Scale (VAS). *Journal of Clinical Nursing*, *10*(5), 706.
27. da Rocha Motta, G., Amaral, M. V., Rezende, E., Pitta, R., dos Santos Vieira, T. C., Duarte, M. E. L., ... & Casado, P. L. (2014). Evidence of genetic variations associated with rotator cuff disease. *Journal of Shoulder and Elbow Surgery*, *23*(2), 227-235. DOI:10.1016/j.jse.2013.07.053
28. D'Addona, A., Maffulli, N., Formisano, S., & Rosa, D. (2017). Inflammation in tendinopathy. *The Surgeon*, *15*(5), 297-302. DOI: 10.1016 / j.surge.2017.04.004
29. Daecke, W., Kusnierczak, D., & Loew, M. (2002). Long-term effects of extracorporeal shockwave therapy in chronic calcific tendinitis of the shoulder. *Journal of Shoulder and Elbow Surgery*, *11*(5), 476-480. DOI: 10.1067/mse.2002.126614
30. de Oliveira, F. C. L., Bouyer, L. J., Ager, A. L., & Roy, J. S. (2017a). Electromyographic analysis of rotator cuff muscles in patients with rotator cuff tendinopathy: A systematic review. *Journal of Electromyography and Kinesiology*, *35*, 100-114. DOI:10.1016/j.jelekin.2017.06.002
31. de Oliveira, F. C. L., de Fontenay, B. P., Bouyer, L. J., Desmeules, F., & Roy, J. S. (2017b). Effects of kinesiotaping added to a rehabilitation programme for patients with rotator cuff tendinopathy: Protocol for a single-blind, randomised controlled trial addressing symptoms, functional limitations and underlying deficits. *BMJ Open*, *7*(9). DOI: 10.1136/bmjopen-2017-017951
32. de Witte, P. B., van Adrichem, R. A., Selten, J. W., Nagels, J., Reijnierse, M., & Nelissen, R. G. (2016). Radiological and clinical predictors of long-term outcome in rotator cuff calcific tendinitis. *European radiology*, *26*(10), 3401-3411. DOI: 10.1007/s00330-016-4224-7
33. Dean, B. J., Franklin, S. L., & Carr, A. J. (2013). The peripheral neuronal phenotype is important in the pathogenesis of painful human tendinopathy: A systematic review. *Clinical Orthopaedics and Related Research*, *471*(9), 3036-3046. DOI: 10.1007/s11999-013-3010-y

34. DeFranco, M. J., & Cole, B. J. (2009). Current Perspectives on Rotator Cuff Anatomy. *The Journal of Arthroscopic & Related Surgery*, *25*(3), 305-320. DOI: 10.1016/j.arthro.2008.07.023
35. Del Castillo-González, F., Ramos-Alvarez, J. J., Rodríguez-Fabián, G., González-Pérez, J., Jiménez-Herranz, E., & Varela, E. (2016). Extracorporeal shockwaves versus ultrasound-guided percutaneous lavage for the treatment of rotator cuff calcific tendinopathy: a randomized controlled trial. *European Journal of Physical and Rehabilitation Medicine*, *52*(2), 145-151.
36. Deprés-tremblay, G., Chevrier, A., Snow, M., Hurtig, M. B., Rodeo, S., & Buschmann, M. D. (2016). Rotator cuff repair: A review of surgical techniques, animal models, and new technologies under development. *Journal of Shoulder and Elbow Surgery*, *25*(12), 2078-2085. DOI: 10.1016/j.jse.2016.06.009
37. Desjardins-Charbonneau, A., Roy, J., Dionne, C. E., & Desmeules, F. (2015). The efficacy of taping for rotator cuff tendinopathy: A systematic review and meta-analysis. *International Journal of Sports Physical Therapy*, *10*(4), 420-433.
38. Desmeules, F., Boudreault, J., Dionne, C. E., Frémont, P., Lowry, V., MacDermid, J. C., & Roy, J. S. (2016). Efficacy of exercise therapy in workers with rotator cuff tendinopathy: A systematic review. *Journal of Occupational Health*, *58*(5), 389-403. DOI: 10.1539/joh.15-0103-RA
39. Dimitrios, S., Ioannis, S., & Kalliopi, S. (2014). A pilot trial to study the effectiveness of an exercise program in the treatment of rotator cuff tendinopathy. *Biology of Exercise*, *10* (2), 69-77. DOI: 10.4127/jbe.2014.0079
40. Djerbi, I., Chammas, M., Mirous, M. P., Lazerges, C., Coulet, B., & Shoulder, F. S. F. (2015). Impact of cardiovascular risk factor on the prevalence and severity of symptomatic full-thickness rotator cuff tears. *Orthopaedics & Traumatology: Surgery & Research*, *101*(6), S269-S273. DOI: 10.1016/j.otsr.2015.06.011
41. El Rassi, G., Matta, J., Haidamous, G., Brogard, P., Clavert, P., Kempf, J. F., & Irani, J. (2016). Arthroscopic treatment of non-homogeneous calcifying tendinitis of the rotator cuff. *SpringerPlus*, *5*(1), 190. DOI: 10.1186/s40064-016-1792-6
42. Factor, D., & Dale, B. (2014). Current concepts of rotator cuff tendinopathy. *International journal of sports physical therapy*, *9*(2), 274-288.

43. Farr, S., Sevelda, F., Mader, P., Graf, A., Petje, G., & Sabeti-aschraf, M. (2011). Extracorporeal shockwave therapy in calcifying tendinitis of the shoulder. *Knee Surgery, Sports Traumatology, Arthroscopy*, *19*(12), 2085-2089. DOI: 10.1007/s00167-011-1479-z
44. Felstead, A. J., & Ricketts, D. (2017). Biomechanics of the shoulder and elbow. *Orthopaedics and Trauma*, *31*(5), 300-305. DOI: 10.1016/j.mporth.2017.07.004
45. Firat, T., & Türker, T. (2012). Is the long sarcomere length responsible for non-traumatic supraspinatus tendinopathy? Potential novel pathophysiology and implications for physiotherapy. *Pathophysiology*, *19*(3), 179-183. DOI: 10.1016/j.pathophys.2012.04.008
46. Franceschi, F., Papalia, R., Paciotti, M., Franceschetti, E., Di Martino, A., Maffulli, N., & Denaro, V. (2014). Obesity and Risk Factor for Tendinopathies: a Systematic Review. *International Journal of Endocrinology*, 1-10. DOI: 10.1155/2014/670262
47. Gerdesmeyer, L., Frey, C., Vester, J., Maier, M., Lowell, W., Weil, L., ... & Gollwitzer, H. (2008). Radial extracorporeal shock wave therapy is safe and effective in the treatment of chronic recalcitrant plantar fasciitis: Results of a confirmatory randomized placebo-controlled multicenter study. *The American Journal of Sports Medicine*, *36*(11), 2100-2109. DOI: 10.1177/0363546508324176
48. Gerdesmeyer, L., Wagenpfeil, S., Haake, M., Maier, M., Loew, M., Wörtler, K., ... & Rompe, J. D. (2003). Extracorporeal Shock Wave Therapy for the Treatment of Chronic Calcifying Tendonitis of the Rotator Cuff. *JAMA: The Journal of the American Medical Association*, *290*(19), 2573-2580. DOI: 10.1001/jama.290.19.2573
49. Goldstein, B. (2004). Shoulder anatomy and biomechanics. *Physical Medicine and Rehabilitation Clinics of North America*, *15*(2), 313-349. DOI: 10.1016/j.pmr.2003.12.008
50. Gumina, S., Arceri, V., Carbone, S., Albino, P., Passaretti, D., Campagna, V., ... & Postacchini, F. (2013). The association between arterial hypertension and rotator cuff tear: the influence on rotator cuff tear sizes. *Journal of Shoulder and Elbow Surgery*, *22*(2), 229-232. DOI: 10.1016/j.jse.2012.05.023

51. Gumina, S., Candela, V., Passaretti, D., Latino, G., Venditto, T., Mariani, L., & Santilli, V. (2014). The association between body fat and rotator cuff tear: the influence on rotator cuff tear sizes. *Journal of Shoulder and Elbow Surgery*, *23*(11), 1669-1674. DOI: 10.1016/j.jse.2014.03.016
52. Haake, M., Deike, B., Thon, A., & Schmitt, J. (2002). Exact Focusing of Extracorporeal Shock Wave Therapy for Calcifying Tendinopathy. *Clinical Orthopaedics and Related Research*, (397), 323-331.
53. Heron, S. R., Woby, S. R., & Thompson, D. P. (2017). Comparison of three types of exercise in the treatment of rotator cuff tendinopathy/shoulder impingement syndrome: A randomized controlled trial. *Physiotherapy*, *103*(2), 167-173. DOI: 10.1016/j.physio.2016.09.001
54. Hinsley, H., Nicholls, A., Daines, M., Wallace, G., Arden, N., & Carr, A. (2014). Classification of rotator cuff tendinopathy using high definition ultrasound. *Muscles, ligaments and tendons journal*, *4*(3), 391-397.
55. Hofstee, D. J., Gosens, T., Bonnet, M., & Malefijt, J. D. W. (2007). Calcifications in the cuff: Take it or leave it?. *British Journal of Sports Medicine*, *41*(11), 832-835. DOI: 10.1136/bjsm.2007.036939
56. Holmgren, T., Öberg, B., Adolfsson, L., Hallgren, H. B., & Johansson, K. (2014). Minimal important changes in the Constant-Murley score in patients with subacromial pain. *Journal of Shoulder and Elbow Surgery*, *23*(8), 1083-1090. DOI: 10.1016/j.jse.2014.01.014
57. Hsu, C. J., Wang, D. Y., Tseng, K. F., Fong, Y. C., Hsu, H. C., & Jim, Y. F. (2008). Extracorporeal shock wave therapy for calcifying tendinitis of the shoulder. *Journal of Shoulder and Elbow Surgery*, *17*(1), 55-59. DOI: 10.1016/j.jse.2007.03.023
58. Huang, S. W., Wang, W. T., Chou, L. C., Liou, T. H., Chen, Y. W., & Lin, H. W. (2016). Diabetes mellitus increases the risk of rotator cuff tear repair surgery: A population-based cohort study. *Journal of Diabetes and its Complications*, *30*(8), 1473-1477. DOI: 10.1016/j.jdiacomp.2016.07.015
59. Ioppolo, F., Tattoli, M., Di Sante, L., Attanasi, C., Venditto, T., Servidio, M., ... & Santilli, V. (2012). Extracorporeal Shock-Wave Therapy for Supraspinatus

Calcifying Tendinitis: A Randomized Clinical Trial Comparing Two Different Energy Levels. *Physical Therapy*, *92*(11), 1376-1385. DOI: 10.2522/ptj.20110252

60. Itoi, E. (2013). Rotator cuff tear: Physical examination and conservative treatment. *Journal of Orthopaedic Science*, *18*(2), 197-204. DOI: 10.1007/s00776-012-0345-2
61. Itoi, E., Minagawa, H., Yamamoto, N., Seki, N., & Abe, H. (2006). Are pain location and physical examinations useful in locating a tear site of the rotator cuff?. *The American journal of sports medicine*, *34*(2), 256-264.
62. Jeong, J., Shin, D. C., Kim, T. H., & Kim, K. (2017). Prevalence of asymptomatic rotator cuff tear and their related factors in the Korean population. *Journal of Shoulder and Elbow Surgery*, *26*(1), 30-35. DOI: 10.1016/j.jse.2016.05.003
63. *Journal of Shoulder & Elbow Surgery*, *24* (12). DOI: 10.1016/j.jse.2015.08.023
64. Kim, E. K., & Kwak, K. I. (2016). Effect of extracorporeal shock wave therapy on the shoulder joint functional status of patients with calcific tendinitis. *Journal of Physical Therapy Science*, *28*(9), 2522-2524. DOI: 10.1589/jpts.28.2522
65. Kim, Y. S., Lee, H. J., Kim, Y. V., & Kong, C. G. (2014). Which method is more effective in treatment of calcific tendinitis in the shoulder? Prospective randomized comparison between ultrasound-guided needling and extracorporeal shock wave therapy. *Journal of Shoulder and Elbow Surgery*, *23*(11), 1640-1646. DOI: 10.1016/j.jse.2014.06.036
66. Kudo, P., Dainty, K., Clarfield, M., Coughlin, L., Lavoie, P., & Lebrun, C. (2006). Randomized, placebo-controlled, double-blind clinical trial evaluating the treatment of plantar fasciitis with an extracoporeal shockwave therapy (ESWT) device: a North American confirmatory study. *Journal of orthopaedic research: official publication of the Orthopaedic Research Society*, *24*(2), 115-123. DOI: 10.1002/jor.20008
67. Lee, S. U., Joo, S. Y., Kim, S. K., Lee, S. H., Park, S. R., & Jeong, C. (2016). Real-time sonoelastography in the diagnosis of rotator cuff tendinopathy. *Journal of Shoulder and Elbow Surgery*, *25*(5), 723-729. DOI: 10.1016/j.jse.2015.10.019
68. Leeman, J. J., Shaw, K. K., Mison, M. B., Perry, J. A., Carr, A., & Shultz, R. (2016). Extracorporeal shockwave therapy and therapeutic exercise for supraspinatus and

biceps tendinopathies in 29 dogs. *The Veterinary Record*, *179*(15), 385-385. DOI: 10.1136/vr.103487

69. Leong, H. T., Hug, F., & Fu, S. N. (2016). Increased upper trapezius muscle stiffness in overhead athletes with rotator cuff tendinopathy. *Plos One*, *11*(5), 1-13. DOI: 10.1371/journal.pone.0155187
70. Leong, H. T., Ng, G. Y. F., Chan, S. C., & Fu, S. N. (2017). Rotator cuff tendinopathy alters the muscle activity onset and kinematics of scapula. *Journal of Electromyography and Kinesiology*, *35*, 40-46. DOI: 10.1016/j.jelekin.2017.05.009
71. Lewis, J. S. (2008). Rotator cuff tendinopathy. *British Journal of Sports Medicine*, *43*(4), 236. DOI: 10.1136/bjsm.2008.052175
72. Lewis, J. S. (2010). Rotator cuff tendinopathy: a model for the continuum of pathology and related management. *British Journal of Sports Medicine*, *44*(13), 918-923. DOI:10.1136/918 bjsm.2008.05481
73. Lewis, J. S., Raza, S. A., Pilcher, J., Heron, C., & Poloniecki, J. D. (2009). The prevalence of neovascularity in patients clinically diagnosed with rotator cuff tendinopathy. *BMC Musculoskeletal Disorders*, *10*(1), 163. DOI: 10.1186/1471-2474-10-163
74. Lewis, J., Mccreesh, K., Roy, J. S., & Ginn, K. (2015). Rotator cuff tendinopathy: Navigating the diagnosis-management conundrum. *Journal of Orthopaedic & Sports Physical Therapy*, *45*(11), 923-937. DOI: 10.2519/jospt.2015.5941
75. Littlewood, C., Ashton, J., Chance-Larsen, K., May, S., & Sturrock, B. (2012). Exercise for rotator cuff tendinopathy: a systematic review. *Physiotherapy*, *98*(2), 101-109. DOI: 10.1016/j.physio.2011.08.002
76. Littlewood, C., Malliaras, P., Bateman, M., Stace, R., May, S., & Walters, S. (2013a). The central nervous system–An additional consideration in 'rotator cuff tendinopathy' and a potential basis for understanding response to loaded therapeutic exercise. *Manual Therapy*, *18*(6), 468-472. DOI: 10.1016/j.math.2013.07.005
77. Littlewood, C., May, S., & Walters, S. (2013b). Epidemiology of rotator cuff tendinopathy: A systematic review. *Shoulder & Elbow*, *5*(4), 256-265. DOI: 10.1111/sae.12028

78. Loew, M., Sabo, D., Wehrle, M., & Mau, H. (1996). Relationship between calcifying tendinitis and subacromial impingement: A prospective radiography and magnetic resonance imaging study. *Journal of Shoulder and Elbow Surgery*, *5*(4), 314-319. DOI: https: 10.1016/S1058-2746(96)80059-0
79. Lohrer, H., Nauck, T., Dorn-Lange, N. V., Schöll, J., & Vester, J. C. (2010). Comparison of radial versus focused extracorporeal shock waves in plantar fasciitis using functional measures. *Foot & Ankle International*, *31*(1), 1-9. DOI: 10.3113/FAI.2010.0001
80. Longo, U. G., Berton, A., Papapietro, N., Maffulli, N., & Denaro, V. (2012). Epidemiology, genetics and biological factors of rotator cuff tears. *Medicine and sport science*, *57*, 1-9. DOI: 10.1159/000328868
81. Longo, U. G., Franceschi, F., Spiezia, F., Forriol, F., Maffulli, N., & Denaro, V. (2010). Triglycerides and total serum cholesterol in rotator cuff tears: Do they matter?. *British Journal of Sports Medicine*, *44*(13), 948-951. DOI: 10.1136/bjsm.2008.056440
82. Lorbach, O., Kusma, M., Pape, D., Kohn, D., & Dienst, M. (2008). Influence of deposit stage and failed ESWT on the surgical results of arthroscopic treatment of calcifying tendonitis of the shoulder. *Knee Surgery, Sports Traumatology, Arthroscopy*, *16*(5), 516-521. DOI: 10.1007/s00167-008-0507-0
83. Louwerens, J. K., Sierevelt, I. N., van Hove, R. P., van den Bekerom, M. P., & van Noort, A. (2015). Prevalence of calcific deposits within the rotator cuff tendons in adults with and without subacromial pain syndrome: clinical and radiologic analysis of 1219 patients. *Journal of Shoulder and Elbow Surgery*, *24*(10), 1588-1593. DOI: 10.1016/j.jse.2015.02.024
84. Mackert, G. A., Schulte, M., Hirche, C., Kotsougiani, D., Vogelpohl, J., Hoener, B., ... & Kneser, U. (2017). Low-energy extracorporeal shockwave therapy (ESWT) improves metaphyseal fracture healing in an osteoporotic rat model. *Plos One*, *12*(12). DOI: 10.1371/journal.pone.0189356
85. Magosch, P., Lichtenberg, S., & Habermeyer, P. (2003). Radial shock wave therapy in calcifying tendinitis of the rotator cuff-a prospective study. *Zeitschrift für Orthopädie und Unfallchirurgie*, *141*(6), 629-636. DOI: 10.1055/s-2003-812407

86. Maier, D., Jaeger, M., Izadpanah, K., Bornebusch, L., Suedkamp, N. P., & Ogon, P. (2013). Rotator Cuff Preservation in Arthroscopic Treatment of Calcific Tendinitis. *Arthroscopy: The Journal of Arthroscopic & Related Surgery*, *29*(5), 824-831. DOI: 10.1016/j.arthro.2013.01.031
87. Maier, D., Jaeger, M., Izadpanah, K., Köstler, W., Bischofberger, A. K., Südkamp, N. P., & Ogon, P. (2014). Arthroscopic Removal of Chronic Symptomatic Calcifications of the Supraspinatus Tendon Without Acromioplasty: Analysis of Postoperative Recovery and Outcome Factors. *Orthopaedic journal of sports medicine*, *2*(5). DOI: 10.1177/2325967114533646
88. Maier, M., Saisu, T., Beckmann, J., Delius, M., Grimm, F., Hupertz, V., ... & Ueberle, F. (2001). Impaired tensile strength after shock-wave application in an animal model of tendon calcification. *Ultrasound in Medicine & Biology*, *27*(5), 665-671. DOI: 10.1016/S0301-5629(01)00348-9
89. Maier, M., Stäbler, A., Lienemann, A., Köhler, S., Feitenhansl, A., Dürr, H. R., ... & Refior, H. J. (2000). Shockwave application in calcifying tendinitis of the shoulder–prediction of outcome by imaging. *Archives of Orthopaedic and Trauma urgery*, *120*(9), 493-498. DOI: 10.1007/s004020000154
90. Malcarney, H. L., & Murrell, G. A. (2003). The rotator cuff: Biological adaptations to its environment. *Sports medicine (Auckland, NZ)*, *33*(13), 993-1002. DOI: 10.2165/00007256-200333130-00004
91. Mallows, A. J., Debenham, J. R., Malliaras, P., Stace, R., & Littlewood, C. (2017). Cognitive and contextual factors to optimize clinical outcomes in tendinopathy. *British Journal of Sports Medicine*. DOI: 10.1136/bjsports-2017-098064
92. Merolla, G., Bianchi, P., & Porcellini, G. (2013). Ultrasound-guided subacromial injections of sodium hyaluronate for the management of rotator cuff tendinopathy: a prospective comparative study with rehabilitation therapy. *Musculoskeletal Surgery*, *97*(1), 49-56. DOI: 10.1007/s12306-013-0259-y
93. Miller, L. E., Parrish, W. R., Roides, B., & Bhattacharyya, S. (2017). Efficacy of platelet-rich plasma injections for symptomatic tendinopathy: systematic review and

meta-analysis of randomised injection-controlled trials. *BMJ Open Sport & Exercise Medicine*, *3*(1). DOI: 10.1136/bmjsem-2017-000237

94. Millett, P. J., & Warth, R. J. (2014). Posterosuperior Rotator Cuff Tears: Classification, Pattern Recognition, and Treatment. *Journal of the American Academy of Orthopaedic Surgeons*, *22*(8), 521-534. DOI: 10.5435/JAAOS-22-08-521
95. Notarnicola, A., Pesce, V., Vicenti, G., Tafuri, S., Forcignanò, M., & Moretti, B. (2012). SWAAT study: extracorporeal shock wave therapy and arginine supplementation and other nutraceuticals for insertional Achilles tendinopathy. *Advances in Therapy*, *29*(9), 799-814. DOI: 10.1007/s12325-012-0046-4
96. Ogden, J. A., Tóth-kischkat, A., & Schultheiss, R. (2001). Principles of shock wave therapy. *Clinical Orthopaedics and Related Research*, *387*, 8-17.
97. Oliva, F., Barisani, D., Grasso, A., & Maffulli, N. (2011). Gene expression analysis in calcific tendinopathy of the rotator cuff. *European cells & materials*, *21*, 548-557.
98. Oudelaar, B. W., Ooms, E. M., Huis, R. M., Schepers-Bok, R., & Vochteloo, A. J. (2015). Smoking and morphology of calcific deposits affect the outcome of needle aspiration of calcific deposits (NACD) for calcific tendinitis of the rotator cuff. *European Journal of Radiology*, *84*(11), 2255-2260. DOI: 10.1016/j.ejrad.2015.07.030
99. Pan, P. J., Chou, C. L., Chiou, H. J., Ma, H. L., Lee, H. C., & Chan, R. C. (2003). Extracorporeal shock wave therapy for chronic calcific tendinitis of the shoulders: a functional and sonographic study. *Archives of Physical Medicine and Rehabilitation*, *84*(7), 988-993. DOI: 10.1016/S0003-9993(03)00010-8
100. Parle, P. J., Riddiford-harland, D. L., Howitt, C. D., & Lewis, J. S. (2017). Acute rotator cuff tendinopathy: does ice, low load isometric exercise, or a combination of the two produce an analgaesic effect?. *British Journal of Sports Medicine*, *51*(3), 208-209. DOI: 10.1136/bjsports-2016-096107.
101. Passaretti, D., Candela, V., Venditto, T., Giannicola, G., & Gumina, S. (2016). Association between alcohol consumption and rotator cuff tear. *Acta Orthopaedica*, *87*(2), 165-168. DOI: 10.3109/17453674.2015.1119599

102. Patte, D. (1990). Classification of rotator cuff lesions. *Clinical Orthopaedics and Related Research*, (254), 81-86.

103. Perlick, L., Luring, C., Bathis, H., Perlick, C., Kraft, C., & Diedrich, O. (2003). Efficacy of extracorporal shock-wave treatment for calcific tendinitis of the shoulder: Experimental and clinical results. *Journal of Orthopaedic Science*, *8*(6), 777-783. DOI: 10.1007/s00776-003-0720-0

104. Pleiner, J., Crevenna, R., Langenberger, H., Keilani, M., Nuhr, M., Kainberger, F., ... & Quittan, M. (2004). Extracorporeal shockwave treatment is effective in calcific tendonitis of the shoulder. A randomized controlled trial. *Wiener Klinische Wochenschrift*, *116*(15-16), 536-541. DOI: 10.1007/BF03217707

105. Porcellini, G., Paladini, P., Campi, F., & Paganelli, M. (2004). Arthroscopic treatment of calcifying tendinitis of the shoulder: Clinical and ultrasonographic follow-up findings at two to five years. *Journal of Shoulder and Elbow Surgery*, *13*(5), 503-508. DOI: 10.1016/j.jse.2004.04.001

106. Rabini, A., Piazzini, D. B., Bertolini, C., Deriu, L., Saccomanno, M. F., Santagada, D. A., ... & Milano, G. (2012). Effects of local microwave diathermy on shoulder pain and function in patients with rotator cuff tendinopathy in comparison to subacromial corticosteroid injections: a single-blind randomized trial. *The Journal of Orthopaedic and Sports Physical Therapy*, *42*(4), 363-370. DOI: 10.2519/jospt.2012.3787

107. Rasmussen, S., Christensen, M., Mathiesen, I., & Simonson, O. (2008). Shockwave therapy for chronic Achilles tendinopathy: A double-blind, randomized clinical trial of efficacy. *Acta Orthopaedica*, *79*(2), 249-256. DOI: 10.1080/17453670710015058

108. Rebuzzi, E., Coletti, N., Schiavetti, S., & Giusto, F. (2008). Arthroscopy surgery versus shock wave therapy for chronic calcifying tendinitis of the shoulder. *Journal of Orthopaedics and Traumatology*, *9*(4), 179-185.

109. Rechardt, M., Shiri, R., Karppinen, J., Jula, A., Heliövaara, M., & Viikari-Juntura, E. (2010). Lifestyle and metabolic factors in relation to shoulder pain and rotator cuff tendinitis: a population-based study. *BMC Musculoskeletal Disorders*, *11*, 165. DOI: 10.1186/1471-2474-11-165

110. Roquelaure, Y., Bodin, J., Ha, C., Petit Le Manac'h, A., Descatha, A., Chastang, J., & ... Imbernon, E. (2011). Personal, biomechanical, and psychosocial risk factors for a rotator cuff syndrome in a working population. *Scandinavian Journal of Work, Environment & Health*, *37* (6), 502-511. DOI: 10.5271/sjweh.3179

111. Rubenthaler, F., Ludwig, J., Wiese, M., & Wittenberg, R. H. (2003). Prospective randomized surgical treatments for calcifying tendinopathy. *Clinical Orthopaedics and Related Research*, (410), 278-284. DOI: 10.1097/01.blo.0000063786.32430.22

112. Rudzki, J. R., Adler, R. S., Warren, R. F., Kadrmas, W. R., Verma, N., Pearle, A. D., ... & Fealy, S. (2008). Contrast-enhanced ultrasound characterization of the vascularity of the rotator cuff tendon: Age-and activity-related changes in the intact asymptomatic rotator cuff. *Journal of Shoulder and Elbow Surgery*, *17*(1), S96-S100. DOI: 10.1016/j.jse.2007.07.004

113. Sabeti, M., Dorotka, R., Goll, A., Gruber, M., & Schatz, K. D. (2007). A comparison of two different treatments with navigated extracorporeal shock-wave therapy for calcifying tendinitis-a randomized controlled trial. *Wiener klinische Wochenschrift*, *119*(3-4), 124-128. DOI: 10.1007/s00508-006-0723-x

114. Sabeti, M., Schmidt, M., Ziai, P., Graf, A., Nemecek, E., & Schueller-Weidekamm, C. (2014). The intraoperative use of ultrasound facilitates significantly the arthroscopic debridement of calcific rotator cuff tendinitis. *Archives of Orthopaedic and Trauma Surgery*, *134*(5), 651-656. DOI: 10.1007/s00402-014-1927-6

115. Sabeti-Aschraf, M., Dorotka, R., Goll, A., & Trieb, K. (2005). Extracorporeal shock wave therapy in the treatment of calcific tendinitis of the rotator cuff. *The American Journal of Sports Medicine*, *33*(9), 1365-1368. DOI: 10.1177/0363546504273052

116. Santander, J., Zarba, E., Iraporda, H., & Puleo, S. (2012). can Arthroscopically Assisted Treatment of Chronic Patellar Tendinopathy Reduce Pain and Restore Function?. *Clinical Orthopaedics and Related Research*, *470*(4), 993-997. DOI: 10.1007/s11999-011-1886-y

117. Saxena, A., Fournier, M., Gerdesmeyer, L., & Gollwitzer, H. (2012). Comparison between extracorporeal shockwave therapy, placebo ESWT and endoscopic plantar fasciotomy for the treatment of chronic plantar heel pain in the athlete. *Muscles, Ligaments and Tendons Journal*, *2*(4), 312-316.

118. Sayampanathan, A. A., & Andrew, T. H. C. (2017). Systematic review on risk factors of rotator cuff tears. *Journal of Orthopaedic Surgery*, *25*(1), DOI: 10.1177/2309499016684318

119. Sconfienza, L. M., Viganò, S., Martini, C., Aliprandi, A., Randelli, P., Serafini, G., & Sardanelli, F. (2013). Double-needle ultrasound-guided percutaneous treatment of rotator cuff calcific tendinitis: tips & tricks. *Skeletal radiology*, *42*(1), 19-24.

120. Scott, A., Docking, S., Vicenzino, B., Alfredson, H., Murphy, R. J., Carr, A. J., ... & Cook, J. L. (2013). Sports and exercise-related tendinopathies: A review of selected topical issues by participants of the second International Scientific Tendinopathy Symposium (ISTS) Vancouver 2012. *British journal of sports medicine*, *47*(9), 536-544. DOI: 10.1136/bjsports-2013-092329

121. Seil, R., Litzenburger, H., Kohn, D., & Rupp, S. (2006). Arthroscopic Treatment of Chronically Painful Calcifying Tendinitis of the Supraspinatus Tendon. *The Journal of Arthroscopic & Related Surgery*, *22*(5), 521-527. DOI: 10.1016/j.arthro.2006.01.012

122. Seitz, A. L., McClure, P. W., Finucane, S., Boardman III, N. D., & Michener, L. A. (2011). Mechanisms of rotator cuff tendinopathy: Intrinsic, extrinsic, or both?. *Clinical Biomechanics*, *26*(1), 1-12. DOI: 10.1016/j.clinbiomech.2010.08.001

123. Sejersen, M. H. J., Frost, P., Hansen, T. B., Deutch, S. R., & Svendsen, S. W. (2015). Proteomics perspectives in rotator cuff research: A systematic review of gene expression and protein composition in human tendinopathy. *Plos One*, *10*(4). DOI: 10.1371/journal.pone.0119974

124. Serafini, G., Sconfienza, L. M., Lacelli, F., Silvestri, E., Aliprandi, A., & Sardanelli, F. (2009). Rotator cuff calcific tendonitis: short-term and 10-year outcomes after two-needle us-guided percutaneous treatment--nonrandomized controlled trial. *Radiology*, *252*(1), 157-164. DOI: 10.1148/radiol.2521081816

125. Seyahi, A., & Demirhan, M. (2009). Arthroscopic Removal of Intraosseous and Intratendinous Deposits in Calcifying Tendinitis of the Rotator Cuff. *The Journal of Arthroscopic & Related Surgery*, *25*(6), 590-596. DOI: 10.1016/j.arthro.2008.12.024

126. Silverstein, B. A., Viikari-Juntura, E., Fan, Z. J., Bonauto, D. K., Bao, S., & Smith, C. (2006). Natural course of nontraumatic rotator cuff tendinitis and shoulder

symptoms in a working population. *Scandinavian Journal of Work, Environment & Health*, *32*(2), 99-108. DOI: 10.5271/sjweh.985

127. Smith, M. A., & Smith, W. T. (2010). Rotator cuff tears: An overview. *Orthopedic Nursing*, *29*(5), 319-22. DOI: 10.1097/NOR.0b013e3181edd8b6
128. Speed, C. A., Nichols, D., Richards, C., Humphreys, H., Wies, J. T., Burnet, S., & Hazleman, B. L. (2002). Extracorporeal shock wave therapy for lateral epicondylitis––a double blind randomised controlled trial. *Journal of Orthopaedic Research*, *20*(5), 895-898. DOI: 10.1016/S0736-0266(02)00013-X
129. Speed, C. (2014). A systematic review of shockwave therapies in soft tissue conditions: Focusing on the evidence. *British Journal of Sports Medicine*, *48*(21), 1538-1542. DOI:10.1136/bjsports-2012-091961
130. Tashjian, R. Z., Farnham, J. M., Granger, E. K., Teerlink, C. C., & Cannon-Albright, L. A. (2016). Evidence for an environmental and inherited predisposition contributing to the risk for global tendinopathies or compression neuropathies in patients with rotator cuff tears. *Orthopaedic Journal of Sports Medicine*, *4*(4). DOI: 10.1177/2325967116642173
131. Terry, G. C., & Chopp, T. M. (2000). Functional anatomy of the shoulder. *Journal of Athletic Training*, *35*(3), 248-255.
132. Uhthoff, H. K., & Matsumoto, F. (2000). Rotator Cuff Tendinopathy. *Sports Medicine and Arthroscopy Review*, *8*(1), 56-68.
133. Vahdatpour, B., Taheri, P., Zade, A. Z., & Moradian, S. (2014). Efficacy of extracorporeal shockwave therapy in frozen shoulder. *International Journal of Preventive Medicine*, *5*(7), 875-881.
134. Vincent, K., Leboeuf-Yde, C., & Gagey, O. (2017). Are degenerative rotator cuff disorders a cause of shoulder pain? Comparison of prevalence of degenerative rotator cuff disease to prevalence of nontraumatic shoulder pain through three systematic and critical reviews. *Journal of Shoulder and Elbow Surgery*, *26*(5), 766-773. DOI: 10.1016/j.jse.2016.09.060
135. Vollans, S., & Ali, A. (2016). Rotator cuff tears. *Surgery (Oxford)*, *34*(3), 129-133. DOI: 10.1016/j.mpsur.2016.01.005

136. Wang, C. J. (2003a). An overview of shock wave therapy in musculoskeletal disorders. *Chang Gung Medical Journal*, *26*(4), 220-232.
137. Wang, C. J. (2012). Extracorporeal shockwave therapy in musculoskeletal disorders. *Journal of Orthopaedic Surgery and Research*, *7*(11), 1-8. doi: 10.1186/1749-799X-7-11
138. Wang, C. J., Ko, J. Y., & Chen, H. S. (2001). Treatment of calcifying tendinitis of the shoulder with shock wave therapy. *Clinical Orthopaedics and Related Research*, (387), 83-89.
139. Wang, C. J., Wang, F. S., Yang, K. D., Weng, L. H., Hsu, C. C., Huang, C. S., & Yang, L. C. (2003b). Shock wave therapy induces neovascularization at the tendon–bone junction: A study in rabbits. *Journal of Orthopaedic Research*, *21*(6), 984-989. DOI: 10.1016/S0736-0266(03)00104-9
140. Weckström, K., & Söderström, J. (2016). Radial extracorporeal shockwave therapy compared with manual therapy in runners with iliotibial band syndrome. *Journal of back and musculoskeletal rehabilitation*, *29*(1), 161-170. DOI: 10.3233/BMR-150612
141. Wells, S. N., Schilz, J. R., Uhl, T. L., & Gurney, A. B. (2016). A literature review of studies evaluating rotator cuff activation during early rehabilitation exercises for post-op rotator cuff repair. *Journal of Exercise Physiology Online*, *19*(3), 70-100.
142. Wendelboe, A. M., Hegmann, K. T., Gren, L. H., Alder, S. C., White, G. L., & Lyon, J. L. (2004). Associations between body-mass index and surgery for rotator cuff tendinitis. *The Journal of Bone and Joint Surgery. American volume*, *86*(4), 743-747.
143. Willberg, L., Sunding, K., Forssblad, M., Fahlström, M., & Alfredson, H. (2011). Sclerosing polidocanol injections or arthroscopic shaving to treat patellar tendinopathy/jumper's knee? A randomised controlled study. *British journal of sports medicine*, *45*(5), 411-415. DOI: 10.1136/bjsm.2010.082446
144. Wilson, C. (2005, May). Rotator cuff versus cervical spine: Making the diagnosis. *The Nurse Practitioner*, *30*(5), 44-50. Retrieved from https://journals.lww.com/tnpj/Citation/2005/05000/Rotator_Cuff_Versus_Cervical_Spine__Making_the.11.aspx

145. Woodley, B. L., Newsham-West, R. J., & Baxter, G. D. (2007). Chronic tendinopathy: Effectiveness of eccentric exercise. *British Journal of Sports Medicine*, *41*(4), 188-198. DOI: 10.1136/bjsm.2006.029769

146. Wu, J. P., Walton, M., Wang, A., Anderson, P., Wang, T., Kirk, T. B., & Zheng, M. H. (2015). The development of confocal arthroscopy as optical histology for rotator cuff tendinopathy. *Journal of Microscopy*, *259*(3), 269-275. DOI: 10.1111/jmi.12260

147. Yamamoto, A., Takagishi, K., Osawa, T., Yanagawa, T., Nakajima, D., Shitara, H., & Kobayashi, T. (2010). Prevalence and risk factors of a rotator cuff tear in the general population. *Journal of Shoulder and Elbow Surgery*, *19*(1), 116-120. DOI: 10.1016/j.jse.2009.04.006

148. Yasin, M. N., Naqui, S. Z., & Muir, L. T. (2010). The reliability of the Constant–Murley shoulder scoring system. *Shoulder & Elbow*, *2*(4), 259-262. DOI: 10.1111 /j.1758-5740.2010.00082.x

149. Yoo, J. C., Park, W. H., Koh, K. H., & Kim, S. M. (2010). Arthroscopic treatment of chronic calcific tendinitis with complete removal and rotator cuff tendon repair. *Knee Surgery, Sports Traumatology, Arthroscopy*, *18*(12), 1694-1699. DOI: 10.1007/s00167-010-1067-7

150. Yuan, J., Murrell, G. A., Wei, A. Q., & Wang, M. X. (2002). Apoptosis in rotator cuff tendonopathy. *Journal of Orthopaedic Research*, *20*(6), 1372-1379. DOI: 10.1016/S0736-0266(02)00075-X

151. Zumstein, M. A., Künzler, M., Hatta, T., Galatz, L. M., & Itoi, E. (2017). Rotator cuff pathology: State of the art. *Journal of ISAKOS: Joint Disorders & Orthapaedic Sports Medicine*, *2*(4), 213-221. DOI: 10.1136/jisakos-2016-000074