Rehabilitative Aspects of Adhesive Capsulitis: Comparison and Effectiveness of Manual Treatment and Surgical Intervention

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***Abstract*—This study analyzes adhesive capsulitis, a condition characterized by pain and reduced joint mobility of the shoulder, with particular attention to therapeutic approaches. The research is structured into six chapters that cover the anatomy and biomechanics of the shoulder, common pathologies, and a clinical case of rehabilitation. Adhesive capsulitis is classified into primary and secondary types, with a focus on its etiopathogenesis and progression stages. Through the analysis of two clinical cases, the differences in rehabilitation treatment plans and the importance of functional assessment are highlighted. The results show that manual treatment is effective in the initial stages, while surgical intervention, such as manipulation under anesthesia and arthroscopic capsulotomy, is recommended in cases resistant to conservative therapy. The research emphasizes the importance of an integrated and personalized approach to optimize functional recovery and the quality of life of patients with adhesive capsulitis. Finally, further studies are hoped for to define standardized management protocols for this condition.**

***Keywords*—Treatments, Adhesive, Capsulitis.**

I INTRODUCTION

This article aims to highlight a pathology that is increasingly frequent in painful shoulder syndromes, which has seen an exponential increase since it was first classified by Duplay in 1896, while the terminology was first used by Codman in 1934 and subsequently modified by Neviaser in 1945, who introduced the term "adhesive capsulitis" to describe a change in the synovium of the glenohumeral joint. Furthermore, the purpose is to emphasize a rehabilitation treatment that is fundamental for the qualitative aspect of a physiotherapist, namely, manual rehabilitation treatment. Throughout the treatment presented in this paper, no machinery of any kind was used, nor were any previous surgical interventions performed. The results confirm that manual treatment can continue to be used as the first choice in the care, rehabilitation, and prevention of adhesive capsulitis.

II KINESIOLOGY AND BIOMECHANICS

Shoulder Function

The shoulder, the proximal joint of the upper limb, is the most mobile joint in our body. It is an enarthrosis (or ball-and-socket joint): enarthroses are particular synovial joints, in which there is an articular surface shaped like a spherical ball that fits more or less snugly within a similarly spherical concave articular surface [1].

It possesses three degrees of movement that allow the orientation of the arm and hand in relation to the three planes of space, thanks to its three main axes:

- The transverse axis, contained within the frontal plane, allows flexion-extension movements performed in the sagittal plane.
- The anteroposterior axis, contained within the sagittal plane, allows abduction and adduction movements in the frontal plane.
- The vertical axis allows flexion-extension movements in the horizontal plane, with the arm in abduction.

The longitudinal axis of the humerus allows for external-internal rotation of the arm and upper limb in two different modalities: voluntary rotation, which uses the third degree of freedom and is possible only in three-axis joints (the enarthroses). This occurs through the contraction of the rotator muscles. Automatic rotation appears without any voluntary action in two-axis joints or even in three-axis joints when these are used like two-axis joints. The referenced position is defined as follows: The upper limb hangs along the body, vertically, such that the longitudinal axis of the humerus coincides with that of the vertical axis. In the abduction position at 90°, the longitudinal axis coincides with the transverse axis. In the flexion position at 90°, it coincides with the antero-posterior axis [1,2].

Therefore, the shoulder is the joint with three main

axes with three degrees of movement; the longitudinal axis of the humerus can coincide with that of one of these three axes or, better, be situated in any intermediate position to allow external-internal rotational movement.

Flexion And Extension Movements

Flexion-extension movements are performed in a sagittal plane around a transverse axis. They are very frequent movements of varying amplitude:

1. Extension: movement of modest amplitude (40° - 50°).
2. Flexion: movement of large amplitude (up to 180°).

Adduction Movements

Adduction in the frontal plane is physiologically impossible due to the presence of the trunk. Starting from a reference position, adduction is possible if combined with movements of:

- Extension: A very modest addition will be achieved.
- Flexion: adduction will be achieved between 30° and 45°.

Starting from any position in abduction, adduction, which will be defined as relative adduction, is always possible in the frontal plane, up to the reference position [2].

Abduction movement

Abduction, the movement that moves the upper limb away from the trunk, is performed in the frontal plane around an antero-posterior axis. The abduction movement reaches 180°, positioning the arm vertically with respect to the trunk. Two important points should be highlighted:

- From 90°, abduction brings the upper limb closer to the body's symmetry plane such that the final position of abduction can be achieved with 180° of flexion;
- From the perspective of muscular action and joint play, abduction passes through three stages:

1) Abduction from 0° to 60°, which can only be performed at the scapulohumeral level.
2) Abduction from 60° to 120°, which requires the co-activation of the scapulothoracic joint.
3) Abduction from 120° to 180°, which involves, in addition to the two previously cited joints, the inclination of the trunk from the opposite side.

Finally, it should be noted how pure abduction, described only in the frontal plane, is a seldom-used movement. On the other hand, abduction combined with a certain degree of flexion of the arm, or elevation in the scapular plane, forming an angle of about 30° anteriorly to the frontal plane, is the most frequent movement to bring the hand to the nape or to the mouth [3].

Rotation Movement

The rotation of the arm around its longitudinal axis can be performed in any position the shoulder is in. This is a voluntary rotation or added joint rotation of the three-axis joints and three degrees of freedom [4].

a) Reference position, termed internal-external rotation at 0°: to measure the rotation movements, the elbow must be flexed at 90°, so as to keep the arm in the sagittal plane. Without this precaution, the amplitude of internal-external rotation movements would add to that of forearm pronation-supination. In practice, the starting position is in internal rotation of 30°, corresponding to the balance of the rotators.

b) External rotation: its amplitude is 80°, never reaching 90°. This total amplitude is rarely used with the arm in the reference position. External rotation, which is the most used and functionally important, is the sector included between the physiological reference position and the classical reference position.

c) Internal rotation: its amplitude ranges from 100° to 110°. To perform it, the forearm must necessarily pass behind the trunk, which combines with a certain degree of shoulder extension. The freedom of this movement is essential for the hand to reach the back.

Clearly, we are discussing rotations from the physiological starting position. It is clear that depending on different situations, the rotator muscles act differently: some lose their rotatory function, while others acquire it. This is just one of the numerous examples of the law of inversion of muscular actions based on position.

Movement of Anteroposition and Retroposition

These movements involve the scapulothoracic joint. The only thing to be emphasized is that anteroposition is broader than retroposition. Regarding muscular action, it is provided by:

- In anteroposition: by the pectoralis major, pectoralis minor, and serratus anterior.
- In retroposition: by the rhomboids, trapezius (transverse bundles), and latissimus dorsi.

Horizontal Flexion and Extension

This is the movement of the upper limb in the horizontal plane around a vertical axis, or more precisely, around a succession of vertical axes since movements are performed not only in the scapulohumeral joint but also in the scapulothoracic joint.

- Reference position: the upper limb is in 90° abduction in the frontal plane, which activates the following muscles: deltoid (acromial bundles), infraspinatus, trapezius (middle and inferior bundles), and serratus anterior.
- Horizontal flexion involves movements that combine flexion and adduction of 140° amplitude, which

engages the following muscles: deltoid (internal and external anterior bundles), subscapularis, major and minor pectoralis, and serratus anterior.

- Horizontal extension involves movements that combine extension and abduction of more limited amplitude from 30° to 40°, engaging the following muscles: deltoid (internal and external posterior bundles), infraspinatus, supraspinatus, major and minor teres, rhomboids, trapezius (middle bundles that add to the other two), latissimus dorsi, which contracts in synergistic antagonism with the deltoid.

The overall amplitude of these horizontal flexion-extension movements reaches up to 180°. From the extreme anterior position to the extreme posterior position, the different bundles of the deltoid are sequentially activated, like the keys of a piano, being the primary muscle responsible for these movements [5].

Circular Movement

Circumduction combines the elementary movements around the three axes. When this circumduction is pushed to its maximum amplitude, the arm describes an irregular cone in space: the cone of circumduction.

This cone delineates, in a sphere centered on the shoulder with a radius equal to the length of the upper limb, a spherical sector of accessibility within which the hand can reach objects without moving the trunk, eventually bringing them to the mouth [6]. During the circumduction movement, the limb crosses the three spatial planes, and the circumduction itself results from the combination of precise movements:

- Flexion-extension in the sagittal plane;
- Adduction and abduction in the frontal plane;
- Horizontal flexion-extension in the horizontal plane.

Codman's Paradox

When starting from a reference position, with the arm along the body, palm facing the trunk, thumb forward, one performs an abduction movement of 180° in the frontal plane, then a relative extension movement in the sagittal plane at 180°, one finds oneself in the position with the upper limb vertical along the body, but with the palm facing outward and the thumb pointing backward. One can then realize the inverse cycle: flexion at 180° and abduction at 180°, resulting in an external rotation of 180°. It is easy to see that the palm has changed orientation and that a longitudinal rotational movement of 180° has been reproduced. In this double movement (abduction first and then extension), an automatic internal rotation of 180° has thus been produced: a subsequent movement around two of the axes of the shoulder, mechanically and therefore without the intervention of will, determines a movement around the longitudinal axis of the upper limb. What McConaill has defined as a joint rotation appears in a sequential movement, which is performed subsequently around the two axes of a joint with two degrees of freedom. In this example, the shoulder joint, which possesses three degrees of freedom, is used as a two-axis joint. If the third axis is used to voluntarily and simultaneously perform a reverse rotation of 180°, the hand returns to the starting position, with the thumb forward, having described an ergonomic cycle; movements of this kind are commonly utilized in performing professional or sports gestures of a repetitive type, for example, swimming. This voluntary longitudinal rotation, which McConaill calls added rotation, is only possible in three-degree-of-freedom joints; this is essential during the execution of an ergonomic cycle [7].

This is well demonstrated in the following experience: starting from the reference position, but in internal rotation, palm outward and thumb back, abduction towards 180°, starting from 90° of abduction, the movement is blocked, and one must voluntarily perform an external rotation to continue. In fact, anatomical reasons, ligamentous tensions, and muscle tensions prevent the joint rotation from continuing in the direction of internal rotation, and one must resort to an external rotation to cancel internal joint rotation and complete the ergonomic cycle. This explains the necessity of a three-axis joint at the root of the limb. In summary, the shoulder is capable of performing two types of longitudinal rotation: voluntary or added rotation and automatic or joint rotation. At every moment, these two rotations algebraically add up: - if the voluntary (added) rotation is null, the automatic (joint) rotation manifests clearly: this is Codman's (pseudo) paradox; if the voluntary rotation is in the same direction as the automatic rotation, it amplifies it; if the voluntary rotation is in the opposite direction, it diminishes or even cancels the automatic rotation: this is the ergonomic cycle.

III SHOULDER DISEASES *(Focus on Adhesive Capsulitis)*

The Shoulder Articular Complex

The shoulder complex is a musculoskeletal complex formed by various bones, muscles, ligaments, and joints. The shoulder complex is indeed formed by the glenohumeral joint (GH), the sternoclavicular joint (SC), and the acromioclavicular joint (AC). Assisting in the action of these three joints are also other structures, such as the scapulothoracic joint (which should not be considered a true joint from an anatomical point of view), as well as various muscles from both the upper limb and the trunk. The movement of these joints is indeed performed through the interaction of approximately 30 muscles. It becomes logical to

understand that any morphological and/or functional alterations to these joints or to the soft components will cause significant dysfunction to the entire complex.

Speaking specifically of the joints, we will see that biomechanically, the primary function of the shoulder complex is to orient the hand in space to carry out normal daily activities.

Another function of the shoulder complex, primarily in sports gestures, such as serving in tennis or throwing a baseball, is to act as a "funnel" through which forces coming from larger body districts (trunk and lower limbs) pass to the arm muscles until reaching the hand [7].

The ability to perform these gestures functionally and correctly is given by the stability of the glenohumeral joint and the mobility that derives from it. Thanks to the bony configuration of the joint, we can classify the shoulder as a more mobile than stable complex, both in its humeral component and in its scapular component. Stability, in fact, depends mainly on the soft tissue structures that compose it, such as the articular capsule, ligaments, and muscles.

Common Pathologies

The shoulder complex can be affected by various pathological conditions, which usually depend on acute trauma or repeated microtrauma. These types of injuries undermine the mobility, dynamic stability, strength, and kinesthesia of the limb. In the assessment of a patient, it is thus of fundamental importance to verify the correct balance between the four joints that work synergistically. It is indeed very easy to find injuries that lead to mechanical alterations: examples include instabilities, pathologies mainly affecting the glenohumeral joint (referred to as glenohumeral instability); SLAP lesions (tears of the glenoid labrum), or more simply, we could find Tendinopathies, Scapulothoracic Dyskinesias (often caused by strong imbalances between muscle groups), and fractures (often of the proximal third of the humerus). Finally, we conclude with the one we will discuss more in the following paragraphs: Adhesive Capsulitis or Frozen Shoulder, a pathology affecting the articular capsule.

Adhesive Capsulitis: Overview and Classification

Adhesive capsulitis is a condition that raises many questions, characterized by pain and a progressive and debilitating loss of active and passive ROM (Range of Motion) of the glenohumeral joint in multiple directions.

Adhesive capsulitis is usually classified as "primary" when it occurs independently of other pathologies, or "secondary" when it arises following trauma or is associated with another injury.

It predominantly affects women aged between 45 and 55. The prevalence of primary adhesive capsulitis has been reported to be between 2.4% and 5.3% of the global population.

Classification according to Landberg

According to Landberg, adhesive capsulitis can be divided into two branches [8]:

- Primary adhesive capsulitis, which, according to him, can be defined as "primary" when shoulder elevation is limited to 135° or less, when the restriction is well localized in the glenohumeral joint area, and when radiographic and clinical investigations do not report the cause of the movement restriction. Conditions such as rheumatoid arthritis, post-traumatic conditions, osteoarthritis, and hemiplegia exclude its belonging.
- Secondary adhesive capsulitis: the ROM is limited following a damaging condition. Associated lesions can include all soft tissue lesions in the shoulder region, intra-articular and extra-articular fractures, and other fractures of the upper limb.

Etiology and Pathogenesis

Adhesive capsulitis typically progresses through a series of phases that correspond to arthroscopic and histological findings.

- *Phase 1* (“painful” or “pre-adhesive”). In this phase, patients often report mild shoulder pain and a consequent decrease in joint ROM; however, patients in this phase of the condition can achieve complete physiological ROM under anesthesia. During this phase, a synovial pathology has been detected through histological analysis, but it is not clear whether this constitutes synovitis or non-inflammatory synovial hyperplasia and angiogenesis. Accurate analyses have established a more significant synovial pathology at the level of the antero-superior capsule. The presence of multiple nerve cells in tissue samples may explain why adhesive capsulitis is so painful.
- *Phase 2* (“freezing”). During this phase, synovial hyperplasia continues, accompanied by fibroblastic proliferation in the underlying joint capsule. The loss of ROM becomes increasingly severe and intense, with or without anesthesia, due to the dense formation of fibrotic scar tissue. This process involves high levels of cytokines that regulate fibroblastic proliferation and collagen synthesis. This proliferative fibrosis is regulated by the immune system. Additionally, the presence of mast cells in tissue samples confirms the hypothesis of an underlying inflammatory process causing capsular fibrosis. High levels of tissue inhibitors of metalloproteinases have been found in subjects with adhesive capsulitis.

These are important for inhibiting those enzymes that remodel the extracellular collagen matrix. Thus, adhesive capsulitis seems to be accompanied by both excessive collagen synthesis and impaired or inadequate remodeling

of the collagen matrix.

- *Phase 3* ("frozen" or "stiffness"). During this phase, the synovial pathology begins to subside, but the adhesions formed in the capsule reduce the intra-articular volume and the capsular adhesion. This results in a marked loss of ROM in the glenohumeral joint, although in this phase, pain tends to stabilize or, in less severe cases, decrease. Glenohumeral retraction is more severe in the anterior portion of the capsule, corresponding to the interval of the rotator cuff and the coracohumeral ligament. The histological appearance of the glenohumeral capsule affected by retraction is very similar to that observed in Dupuytren's disease, leading to the idea that the molecular biology of these disorders is roughly similar.
- *Phase 4* ("thawing"). During this phase, also termed recovery, the mobility of the glenohumeral joint and the shoulder in general improves. Characteristic elements of this last phase are certainly painless stiffness and a progressive increase in ROM.

The duration of these phases, which is always subjective, follows a long course of about two years, divided as follows:

- PHASE 1: from 0 to 3 months;
- PHASE 2: from 3 to 9 months;
- PHASE 3: from 9 to 15 months;
- PHASE 4: from 15 to 24 months.

The pathogenesis of capsulitis has not been firmly established, but numerous causal factors have been identified, such as immune disorders, autonomic neuropathies, shoulder immobilization, trauma, suprascapular nerve compression neuropathies, psychogenic disorders, and trisomies of chromosomes 7 and 8.

Among the risk factors or coinciding with the pathological process are: Diabetes, thyroid dysfunctions, Dupuytren's disease, Parkinson's disease, osteoporosis, osteopenia, cardiorespiratory issues, stroke, hyperlipidemia, low production of adrenocorticotropic hormone, cardiac surgery interventions, and neurosurgery [8].

Clinical Manifestation

The onset of adhesive capsulitis is often insidious, although any previous injuries or coinciding medical-clinical situations should be investigated. The severity of symptoms and clinical outcomes is closely related to the phase in which the condition is located and the moment the examination is performed [8].

As in other pathologies of the glenohumeral joint, the patient usually reports rather diffuse shoulder pain, with localized soreness in the area adjacent to the deltoid tuberosity of the humerus that may occasionally radiate to the elbow region. The pain generally increases with movement and decreases with rest, except at night, when the pain may even disrupt sleep. Typically, there is difficulty in performing daily activities, particularly those that require actions behind the back, above the head, or on the opposite side of the body. As symptoms progress, patients find it increasingly difficult to find a comfortable position for the arm (usually adducted and anteposed).

Limitations of both active and passive ROM are frequent, in multiple directions of movement. Reductions greater than 50% have been reported. It is also common for an increase in mobility of the scapulothoracic joint to occur, likely to compensate for the loss of glenohumeral ROM. The strength of the shoulder may be compromised by adhesive capsulitis, especially at the level of the internal glenohumeral rotators and flexors. The ROM of external rotation with the arm along the side (neutral position) often appears significantly reduced. This aspect, specific to capsulitis, is due to tissue retraction in areas such as the interval of the rotator cuff and the coracohumeral ligament.

Diagnostic Methods

The primary aim of the diagnosis is to guide the rehabilitative intervention and prognosis. As already mentioned, a classification scheme for adhesive capsulitis distinguishes it into primary and secondary types. While for the primary type we refer to an idiopathic condition, when dealing with secondary adhesive capsulitis, three subcategories need to be distinguished: intrinsic, extrinsic, and systemic. We refer to systemic capsulitis when it is correlated with a systemic pathology, such as diabetes or hypo/hyperthyroidism. It is identified as extrinsic capsulitis when shoulder pain is related to one or more pathologies that do not directly affect the upper limb. Examples include cerebrovascular accidents (strokes), thoracic pathologies (IMA, COPD), and cervical spine dysfunctions. When referring to intrinsic capsulitis, we are referring to all shoulder pathologies that cause movement restrictions and immobility. Among these, we can list: soft tissue pathologies, rotator cuff tendinopathies, calcific tendinopathies, and arthropathies of the acromioclavicular or glenohumeral joints. The diagnosis is therefore strictly clinical. Imaging and MRI are used only to exclude the coexistence of other pathologies affecting the shoulder. Ultrasound may only help confirm the clinical diagnosis of adhesive capsulitis. In ultrasound imaging, we often observe a thickening of the coracohumeral ligament, the presence of hypoechoic vascular soft tissue in the interval of the rotator cuff, and limited sliding of the supraspinatus tendon in contact with the acromion. Few studies have investigated the relationship between clinical phases and ultrasound findings. Zappia et al. [9] showed that the interval of the cuff was thicker in phase 1 compared to phase 2, and the coracohumeral ligament was significantly thicker in phase

1 compared to normal. Furthermore, thickened synovium and synovial proliferation with adhesion in the cuff interval were observed in phase 2. Thickening of the axillary pouch, according to our practical observations, was seen in phases 1 and 2. This suggests that synovial inflammation and proliferation affect the thickness of the cuff interval and the coracohumeral ligament in the second phase of the disease.

IV CLINICAL CASE AND PHYSIOTHERAPY REHABILITATION

Description of the Clinical Case

For the preparation of this article, two clinical cases were analyzed: one female and one male. Both diagnosed with adhesive capsulitis, they reported severe pain in the affected shoulder during the objective examination, with pain radiating down to the elbow, and a significant reduction in strength and joint ROM, notably in the case of the female patient, moderate in the case of the male [9].

Initial Patient Assessment

For the initial assessment, a diagnostic/evaluative scale designed and tested on patients with adhesive capsulitis by the Villa Sandra assistance association (San Giovanni La Punta, CT) was administered. Within it, following a careful objective examination regarding mobility and muscle strength, we proceed to collect anamnesis data, such as the presence of cardiovascular pathologies, the coexistence of conditions such as Diabetes, Hypothyroidism, and Hyperthyroidism, and Dupuytren's disease. Subsequently, our investigation shifts to the clinical history of the patient, especially past diagnostic investigations, any previous rehabilitative interventions (physical therapies, infiltrations, physiotherapy), and occupational activity. In addition to these, after collecting all data regarding ROM and mobility, two pain measurement scales are administered.

The first is the VAS (Visual Analog Scale), the second, more specific, is the DASH (Disability of the Arm, Shoulder, Hand).

Joint ROM Assessment

The anamnesis and clinical measurements before the rehabilitative treatment indicated these values.

Patient No. 1 (F) MOVEMENTS
Patient No. 2 (M)

100°	Flexion	135°
90°	Abduction	115°
40°	External Rotation 0°	60°
30°	External Rotation 90°	50°
40°	Internal Rotation 90°	45°
20°	Horizontal Adduction	35°

1

From these ROM measurements, we can already observe how different the two rehabilitative cases are. The difference, in addition to the degrees lost in shoulder movements, lies in the fact that patient No. 1 presents a much more significant and irritable capsular stiffness compared to the second patient. This has resulted in the rehabilitative treatment differing significantly between the two patients. Data shows that if for patient No. 1 the limitations are significant across all shoulder movements, for patient No. 2, the major issues are found in Abduction and Internal Rotation. This was obviously taken into consideration during treatment to focus particularly on the most limited movements.

Evaluative Scales

Both patients underwent functional evaluation through a document developed as previously mentioned by the Villa Sandra assistance association (San Giovanni La Punta, CT). Within it, there are two scales for measuring pain (VAS) and measuring shoulder disability (DASH-Score).

	VAS	DASH
PT. 1	10/10	85/100
PT. 2	8/10	65/100 2

head; Elevation in the frontal plane;

- Adduction in the scapular plane;
- Antero-retroposition translations of the humeral
- External rotation at 0°, 45°, 90°.

Lateral Decubitus Position on the Healthy Side:

- Adduction in the scapular plane;
- Stretching maneuvers for the rotator cuff

Again, we see how the perception of pain and disability is evaluated differently and by the patient. Both the ROM and the pain and disability assessments will be repeated at the end of the rehabilitative treatment to evaluate the progress achieved.

Rehabilitation Treatment Plan

After the careful analysis performed during the assessment, the two patients embarked on the same rehabilitative project. The difference in starting conditions and the particular rigidity of the female patient's articular capsule, as mentioned above, necessitated a different timing in the rehabilitative treatment. Regarding the rehabilitation treatment, the female patient underwent 3 weekly sessions for about 4 continuous months. The same weekly frequency, but for a total of 20 sessions for the male patient instead. The chosen rehabilitative treatment consists of different phases, each clearly adapted to the progress that genuinely improved the patients' quality of life month after month. Each session is divided into several phases that we will now analyze.

It was decided, in agreement with the orthopedic doctor, to precede the start of treatment with a warm compress

to be applied to the affected shoulder area for about 15 minutes, in order to promote tissue elasticity and provide relief to the patient. Immediately after this "Pre-Phase," we proceed to capsular stretching.

Phase 1: Capsular Stretching.

In this first phase, the patient lies on the treatment table in a supine position with bent legs, in order to place as little strain as possible on the spinal column and to almost eliminate all compensations that the patient may employ in response to the pain caused by capsular stretching.

The mobilizations are always performed respecting the patient's tolerance and irritability, always at "end range," in all directions of space, and affecting all capsular portions. The most rigid portion has been localized, through manipulations and capsular stretching, in the posteroinferior direction. The physiotherapy intervention has thus been executed.

Supine Position:

- Abduction in the scapular plane; interval;
- Internal rotation with the arm behind the body;
- Scapular manipulation:
- Coaptation and decoaptation of the humeral head.

Lateral Decubitus Position on the Affected Side:

- External rotation with the elbow resting on the treatment table;
- Internal rotation with the elbow resting on the treatment table.

Prone Position:

- Internal rotation with the arm behind the body;
- Elevation with the arm extending from the treatment table;
- External rotation with the elbow flexed at 90° (the arm extending from the treatment table);
- Internal rotation with the elbow flexed at 90° (the arm extending from the treatment table).

At the end, the patient will perform pendulum exercises of Codman while remaining in the prone position, with the affected arm extending from the treatment table, with or without weights (max 1kg).

In a second rehabilitative moment, movements will start to be combined during capsular stretching, for example, in the supine position, abduction and external rotation movements; in the prone position, retroposition and rotation movements, to be even more selective on the capsular district to be stretched.

Phase 2: Exercises in Front of the Mirror with Body Weight

After the first phase of passive stretching on the treatment table, performed by the physiotherapist, we will move our patient in front of the mirror. Here, they will be able to perform independently (so they can also repeat them at home) some self-correction exercises.

- Exercise 1: The patient must lift both shoulders while keeping both upper limbs in a neutral position with the palm of the hand facing the trunk.
- Exercise 2: The patient must perform a combined retroposition movement of both shoulders, bringing both scapulae closer to the median axis of the body, ideologically represented by the spinal column.
- Exercise 3: The patient must manage to perform a depression and lowering movement of the shoulders. The position remains unchanged compared to exercises 1 and 2.
- Exercise 4: This last exercise involves circumductions in both directions, starting from the reference position used for all three previous exercises.

Phase 3: Exercises with a Stick

Following capsular stretching and body weight exercises in front of the mirror, patients were provided with a one-meter-long wooden stick with a diameter of

4 cm. Through this stick, the patient, entirely independently, performs self-stretching exercises for the articular capsule.

- Exercise 1: The patient places the hand of the affected limb at the upper end of the stick, with the healthy limb gripping it at the lower end. The goal of this exercise is to perform anterior elevation stretching that will occur through passive load transfer. With the healthy limb, they push the affected limb upwards to stretch the postero-inferior portion of the capsule.
- Exercise 2: The patient places the stick behind their back, gripping it with both hands. The palm of the limb affected by capsulitis faces backward, while that of the healthy limb faces forward. The target of this exercise is undoubtedly the internal rotation movement. With the healthy limb elevating the stick upward, the shoulder affected by capsulitis performs a totally passive internal rotation movement that stresses the anterior portion of the capsule in stretching.
- Exercise 3: In this last exercise with the stick, the patient holds the stick in front of their body, with the elbows flexed at 90°, adhering closely to the trunk. The movement to perform is that of external rotation of the affected limb. This occurs once again in a completely passive manner, through the push from the healthy limb towards the side affected by capsulitis, thus stretching the antero-superior portion of the articular capsule.

These exercises do not have an exact number of repetitions, but patients perform them for about 15 minutes, alternating with 1-minute breaks between each exercise.

Phase 4: Self-Stretching Exercises

In this phase of the typical rehabilitative session, we will provide the patient with two easily available aids that the patient can procure to repeat the exercises at home. We refer to a pulley and a fitball.

- Exercises with Pulley: These are self-stretching exercises that, as in the case with the stick, leverage the strength of the healthy limb and the principle of load transfer to make the affected capsule perform anterior elevation and abduction movements, so as to stretch the capsule in all its portions. The first exercise sees the patient positioned leaning against a wall or a ladder, with slightly bent knees in a semi-squat position. Through the pulley, they push down on the healthy limb to elevate the affected limb in front. The same occurs for abduction. By changing the position of their hands in space, the patient, with both limbs in 90° abduction, pushes down on the healthy limb to complete or reach the maximum possible ROM in abduction with the affected limb.

- Exercises with a Fitball: The patient in these exercises sits on a chair with the fitball between their legs. They will place both hands above the ball and, through a forward push of the trunk, will stretch both the healthy and affected limbs again in elevation. They must keep their elbows well extended, so as not to create compensations that could mislead the results obtained.

- Self-Stretching Exercises: These are exercises that the patient can repeat entirely independently at home. Exercise 1 involves stretching the posterior capsule. After placing the hand of the affected limb on the opposite shoulder, the patient will, with the healthy limb, attempt to push the hand toward the scapula, thus stretching the posterior portion. Lying on the bed, they will insist on rotation movements, both internal and external, through the push of the healthy limb. They will lie on their side on the affected side, with the arm extending from the treatment table, the elbow flexed at 90°. It will be sufficient to push toward the sacrum or toward the skull to achieve the two rotations.

Again, we do not have a precise number of repetitions, but we prefer that patients spend about 20 minutes on this phase, alternating exercises with about 1-minute breaks.

- Wall Stretching: These are two very simple exercises that can be easily performed frequently throughout the day. The first sees the patient flex the shoulder and thus the arm as much as possible and rest it against a wall, placed laterally to the patient's body while standing. By pushing their body, they progressively stretch the articular capsule. The second exercise sees the patient positioned at a 45° angle to the same wall with the arm flexed horizontally in abduction in order to stretch the anterior portion of the capsule.

- Pendulum Exercises: The patient, standing, bends forward at about 45°. From this starting position, with relaxed arms along the body, they must perform circular swings, in either direction, with the affected limb. This should be repeated about 20-25 times in each direction. This exercise can also be repeated at home.

- Anterior Elevation Exercise: The patient stands facing a wall. In this very simple and reproducible exercise at home, they must anteriorly elevate the shoulder. They will do this by moving an object upwards (e.g., a small ball or an overball) or simply sliding their hand upwards. This exercise can be replaced or alternated with other forms. Another example sees the patient lying supine on a bed. Through the healthy limb, they will need to push the affected limb upwards in elevation.

- Anterior Stretching Exercise: In this exercise, the patient must place both hands behind the neck. The exercise involves alternating between bringing the two elbows closer and further away from the midline axis, in order to stretch and relax both the anterior and posterior portions of the articular capsule. It can be performed both on the treatment table while lying supine and in a standing position, aided by leaning against a wall.

Phase 5: Muscle Strengthening.

Clearly, in the initial moments of rehabilitation, this phase should be excluded. However, once a large part of the joint ROM has been recovered, muscle-strengthening exercises may be initiated without any problem. For these, a few instruments are used, such as elastic bands or therabands, light weights (max 1kg), and an overball. The exercises are varied; here follows a list of the most commonly used.

- Exercise 1: The patient stands with the arm extended along the body. Gripping a 1kg dumbbell, they will perform rotations, both internal and external, at 0°, thereby stimulating the rotation of the humeral head, activating the rotator cuff muscles and their synergy.

- Exercise 2: The patient stands with the elbow flexed at 90° and the arm attached to the body. Holding a 1kg dumbbell, they will strengthen the internal and external rotatory components of the shoulder muscles through active movements. This exercise should be repeated for both internal and external rotation.

- Exercise 3: For this exercise, they will use an overball. They will position themselves facing the wall, in a space that provides full freedom of movement. The

overball will be gripped by the hand of the affected limb, and they must perform the full ROM in abduction, rolling it against the wall. Clearly, this exercise is performed by those who have completed the recovery of ROM in abduction and are in an advanced stage of rehabilitation. A few repetitions are sufficient to work adequately on coordination and the synergy of the rotator cuff muscles.

For this series of exercises, the patient uses an elastic band. Clearly, the resistance should be selected based on the patient in front of you; in this case, it is adequate for the type of patient using it, with the male patient having a greater resistance, given the greater mobility. The exercises the patient will perform are various.

- Exercise 4: Anterior Flexion. The patient attaches the elastic band to a wall ladder at a height of about 120 cm. Holding the elastic band, they must perform an anterior elevation movement. They will then position themselves standing with the wall ladder behind them.
- Exercise 5: Extension. Same position as exercise 4, but this time the patient faces the wall ladder. With the arm extended, they work the component of the latissimus dorsi.
- Exercise 6: With elbows flexed, we will ask the patient to retract their shoulders backward, working on the latissimus dorsi and the humeral depressors.
- Exercise 7: Finally, we also work on rotations. Using an elastic band, one can choose to isolate the movement to a single limb, with the elbow flexed at 90° and the arm abducted at 90°, performing both external and internal rotation movements. If a theraband is used, both movements can be performed simultaneously.

Phase 6: Ice and End of Treatment.

After about an hour, the patients have completed their standard session. In accordance with the orthopedic doctor, just as hot compresses were applied at the beginning of therapy, we suggest an ice pack to be kept on the shoulder for about 12-15 minutes, in order to relax the joint that has worked hard. This should be repeated several times throughout the day, especially after exercises performed at home.

V FURTHER CONSERVATIVE TREATMENTS FOR FROZEN SHOULDER

Pharmacological Therapy: NSAIDS

NSAIDs (non-steroidal anti-inflammatory drugs) are often the first medications taken by patients to relieve pain caused by adhesive capsulitis. Currently, there are very few studies evaluating the effectiveness of NSAIDs for the treatment of adhesive capsulitis. Despite this, NSAIDs typically provide short-term pain relief during the early inflammatory phases of the condition and can be useful to allow patients to tolerate early physiotherapy.

Initial studies reported an improvement in pain relief with NSAIDs and an improvement in shoulder abduction, but relief was not observed after 6 weeks. A second study showed no improvements in either range of motion or pain relief between oral steroids and placebo. The third study indicated that oral steroids, compared to no treatment, provided significant initial pain relief, but these results faded within 5 months. Considering these findings and the fact that NSAIDs had minimal adverse effects, they are recommended as a good therapeutic option for a short period, less than 6 weeks. It is important to note that none of the studies considered used the same doses and intervals for steroid administration. Therefore, there is insufficient evidence to support the superiority of any studied treatment.

Intra-Articular Corticosteroid Injection

Intra-articular corticosteroid injection may offer more rapid and superior symptom improvement compared to treatment with NSAIDs. Intra-articular steroid injections have been shown to reduce fibromatosis and myofibroblasts in adhesive shoulders. Intra-articular methylprednisolone injections have been shown to provide quicker improvement in pain and range of motion compared to physiotherapy, ice therapy, and no treatment. There does not seem to be a difference among these three treatment modalities at 6 months follow-up, although intra-articular corticosteroid injections improve range of motion both in the short and long term [10].

The improvement in ROM in the injection group was assessed regarding abduction, flexion, external and internal rotation.

- The range of abduction, both at 0-8 weeks and at 9-24 weeks, in the injection group was greater than in the control group.
- The range of flexion, both in short-term and long-term follow-up, was greater than in the control group.
- The range of external rotation at both 0-8 weeks and at 9-24 weeks for the injection group was greater than in the control group.
- The range of internal rotation at 0-8 weeks was greater in the injection group, but there was no difference between the two groups at 9-24 weeks.

This review of existing RCT literature and non-randomized prospective controlled trials revealed that intra-articular corticosteroid injections led to improvements in clinical measures of ACS based on VAS scores and ROM, but this improvement was different in short-term and long-term follow-up. At 0-8

weeks of follow-up, both VAS scores and ROM improved with intra-articular corticosteroid injection compared to the control group. However, at 9-24 weeks of follow-up, ROM improved, but there was no difference between injection and control treatments in VAS scores.

Recently, there may be additional benefits from imaging-guided corticosteroid injections, but further investigations are needed [11].

Moreover, it has been shown that when used in conjunction with other treatment modalities, intra-articular corticosteroid injections can provide added benefits. In a recent study comparing the efficacy of a single intra-articular corticosteroid injection, a supervised physiotherapy program, a combination of both, and a placebo in the treatment of adhesive capsulitis, it was shown that a single corticosteroid injection combined with a simple home exercise program was more effective than supervised physiotherapy alone.

Intra-Articular Sodium Hyaluronate Injection

Sodium hyaluronate is an unbranched polysaccharide and a natural component of connective tissue considered chondroprotective. Physiologically, hyaluronate can exert metabolic effects on articular cartilage, synovial tissues, and synovial fluid [12]. Additionally, it has been shown that the injection of hyaluronate reduces the improvement coefficient in dynamic MRI images. The improvement coefficient is a radiological marker for inflammation and, more specifically, is used as a measure of synovitis. Recent studies have shown that hyaluronate injections have been beneficial and led to improvements in range of motion and pain scores. Similar to corticosteroid injections, hyaluronate injections appear to provide improvements only in the short term. In long-term follow-up, hyaluronate injections did not provide any additional benefit when compared to other conservative treatment options. When compared to corticosteroid injections, hyaluronate injections have been shown to have equivalent results with improvements in joint mobility (ROM) and pain scores. Furthermore, it has been found that hyaluronate is safe and does not present reported adverse effects or complications.

Botulinum Toxin Type A

Botulinum toxin is a proven and widely used treatment for numerous conditions characterized by excessive muscle contractions. Several studies have evaluated whether botulinum toxin has effects on joint pain, including randomized controlled studies specifically examining adhesive capsulitis. A recent review of the international literature has shown that the number of randomized studies and sample sizes is too small to provide a satisfactory level of scientific evidence or statistical power [12].

Suprascapular Nerve Block (SSNB)

The suprascapular nerve block (SSNB) is another treatment modality that allows for the treatment of adhesive capsulitis (AC). The primary goal is to provide pain relief to facilitate early movement of the affected shoulder joint. The block affects the nerves of the glenohumeral joint as they branch from the suprascapular nerve. The suprascapular nerve provides nearly 70% of the nerve fibers to the shoulder joint. The technique can be performed blindly, often targeting the supraspinous fossa, but today it is often performed with ultrasound guidance to allow for better visualization of the nerve. The SSNB is a safe and effective modality for treating AC. A 2012 study found that the injection of 40 mg of methylprednisolone acetate and 5 mL of 1% lidocaine into the suprascapular nerve resulted in significant pain reduction and increased shoulder mobility in patients with AC. A randomized controlled trial from 2015 found that SSNB allowed for more aggressive and early physiotherapy. The study compared SSNB with SSNB and physiotherapy, finding a significant reduction in pain among patients receiving SSNB with physiotherapy compared to those receiving only the nerve block. A comparative study from 2016 measured the effects of SSNB versus intra-articular steroid injections and found that while both were effective, SSNB provided faster pain relief, earlier improvements in range of motion, and fewer contraindications/adverse effects. A recent study from 2019 showed that combining both SSNB and an intra-articular steroid injection provided significantly better results in terms of pain and functionality. SSNB is considered an effective and safe procedure for the treatment of AC and can help the patient tolerate more aggressive physiotherapy [13].

Intra-Articular Distension

Hydrodistension is a minimally invasive technique performed in an outpatient setting that involves the injection of a combination of saline solution, corticosteroids, and anesthetic into the shoulder joint, which can increase hydrostatic pressure and the volumetric capacity of the joint, providing rapid relief. Ultrasound-guided injection has proven to be more reliable than unguided injection and faster than fluoroscopically guided injection, making it the preferred method. A Cochrane review showed that hydrodistension with saline solution and steroids in patients diagnosed with frozen shoulder reduces pain after 3 weeks and disability after 12 weeks. Ladermaan et al. recently confirmed this conclusion. Although it is a relatively quick procedure, hydrodistension is not without adverse events. In

particular, it can cause increased pain or rupture of the joint. Additionally, it is more expensive compared to other non-invasive therapies.

Associated with infiltrative treatment, physiotherapy is gaining increasing importance. Therapist-guided interventions usually consist of patient education and passive and active mobilization of the joint. Exercise therapy is effective in reducing pain and disability in various shoulder conditions and is usually part of a multimodal program. The most common types of exercises are isometric exercises or strengthening of the rotator cuff, trapezius, scapular, and glenohumeral muscles, Codman pendulum exercises, and stretching exercises. The goal of these exercises is to improve the range of motion and muscle function by restoring the mobility and stability of the shoulder.

There is a lack of consensus regarding the appropriate suggested intervention for each phase. It is crucial to emphasize the importance of early diagnosis in patients with adhesive capsulitis, highlighting how a delayed diagnosis with the transition from phase 1 to phase 2 can lead to prolonged physiotherapy and infiltrative treatments [13].

Immediately after infiltration, patients are ready to begin rehabilitation treatment.

The rehabilitation protocol consists of a series of pendulum exercises and passive/active glenohumeral mobilization exercises (external and internal rotation, anterior elevation, and retroposition) to be performed twice a day for 15 minutes per session.

The exercises are:

- Pendulum Exercises: The patient bends forward so that they are parallel to the floor and supports themselves on a stool or table with the healthy arm. They swing the affected limb back and forth for about 5 minutes. With the treated limb, the patient makes outward circles with the palm facing outward, then inward circles with the palm.
- External Rotation Exercises: The patient is supine, with the arm close to the body and the elbow flexed at 90°. The patient takes a stick with the healthy limb and places it on the palm of the affected limb, pushing it to hyper-rotate the affected limb. The patient maintains this position for about 15-20 seconds and then returns to the starting position.

-Exercises for Anterior Elevation: In an upright position, the patient holds a stick with both hands, raises their arms above their head as high as possible, maintaining the position for about 10 seconds before returning to the starting position.

-Internal Rotation Exercises: The patient places the affected limb behind their back with the elbow bent. Using a towel and the healthy limb, they bring the affected limb to maximum internal rotation, holding this position for about 5 seconds.

-Retraction Exercises: In an upright position, the patient grabs a stick behind their back with both hands and moves their shoulders to maximum retraction, holding this position for 5 seconds.

-Abduction Exercises: Standing next to a wall with the elbow flexed at 90°, the patient pushes the elbow and forearm against the wall.

The described procedure has proven effective in significantly increasing shoulder range of motion in all planes except extension, significantly reducing pain and significantly increasing shoulder function, as indicated by the SPADI and ASES scores (DASH, while showing substantial improvement, did not reach statistical significance). Treatment analysis in the two phases (phase 1 freezing and phase 2 frozen) showed similar efficacy of therapy. ROM improved considerably in both groups after infiltrative treatment, which reduced differences between phase 1 and phase 2 at the first follow-up and nearly eliminated differences at the second follow-up. However, despite treatment, a persistent reduction in internal and external rotation was found in phase 2 patients, leading all these patients to be treated multiple times with hydrodistension. These data underline the importance of early diagnosis to provide the patient with the best outcome.

Bryant et al. evaluated the effectiveness of ultrasound-guided hydrodistension (with 10 ml of 1% lidocaine followed by 40 mg of triamcinolone acetonide and then 20 ml of 0.9% NaCl) with a posterior approach, followed by guided physiotherapy exercises, in patients with adhesive capsulitis. They documented a significant and sustained increase in SPADI scores, a significant increase in quick DASH scores, and a clinically significant increase in external rotation, flexion, and abduction, all compared to baseline at 6 weeks, 3 months, and 6 months. They were unable to assess the effectiveness of phase 1 treatment compared to phase 2 treatment.

Other studies highlight how delayed diagnosis can lead to repeated infiltrative treatments, associating glenohumeral joint hydrodistension with prolonged physiotherapy for many months. These studies aim to emphasize how ultrasound-guided hydrodistension and physiotherapy are essential treatments for adhesive capsulitis, but early diagnosis is the key element in reducing treatment time and pain, achieving a better response to infiltrative treatment associated with early rehabilitation, without acting on the histopathological nature of the condition.

Shockwave Therapy

In recent years, shockwave therapy has emerged as one of the non-invasive treatment options to alleviate the symptoms of frozen shoulder. This therapeutic approach uses high-energy acoustic waves to stimulate tissue

healing, reduce inflammation, and improve blood circulation in the affected area.

Shockwave therapy involves the administration of acoustic pulses that penetrate tissues, promoting cell regeneration and accelerating the recovery process. Shockwaves may help break adhesions and scars present in the joint capsule, thus improving shoulder mobility. Additionally, they stimulate collagen production, which is essential for repairing damaged tissues [14].

Therapy Advantages Non-Invasive: Unlike surgical interventions, shockwave therapy is a non-invasive method, involving few risks and minimal side effects.

1. Pain Reduction: Many patients report significant pain improvement after just a few sessions.
2. Restoration of Mobility: With appropriate treatment, it is possible to regain a greater range of motion, facilitating daily activities.

While shockwave therapy represents a promising option for treating frozen shoulder, it is essential to consult a specialist for an accurate assessment and a personalized treatment plan. As with any therapy, results may vary from person to person, and it is often advisable to combine it with other therapeutic modalities, such as physiotherapy, to achieve better long-term results.

Robotic Rehabilitation

In recent years, robotic rehabilitation has gained attention as a potential solution to improve outcomes in patients with frozen shoulder. Robotic devices are designed to assist, guide, and monitor patient movements during therapy, offering several advantages over traditional methods.

Advantages of Robotic Rehabilitation

1. Precision and Control: Robotic devices can provide precise control of movements, allowing for treatment customization based on the specific needs of the patient. This targeted approach can enhance rehabilitation effectiveness.
2. Real-Time Feedback: Many robotic systems are equipped with sensors that provide real-time feedback on the patient's progress. This enables physical therapists to immediately adjust the rehabilitation program, increasing patient motivation and engagement.
3. Safe and Repetitive Exercises: Robotic rehabilitation allows for the safe execution of repetitive exercises, reducing the risk of injury. This is particularly important for patients with frozen shoulder, who may be reluctant to perform exercises due to pain.
4. Increased Treatment Adherence: Interaction with robotic technology can make rehabilitation more engaging and interesting for patients, increasing their adherence to the treatment program.

Considerations and Future of Robotic Rehabilitation

While robotic rehabilitation offers promising advantages, it is important to also consider the limitations and challenges associated with this technology. Economic accessibility, the need for proper training for physical therapists, and the integration of robotic devices into existing treatment protocols are crucial aspects to address.

Moreover, research is still in development, and larger clinical studies are needed to confirm the efficacy of robotic rehabilitation in managing frozen shoulder. However, preliminary results are promising and suggest that this technology could represent a significant shift in how we treat this condition.

Frozen shoulder is a debilitating condition that requires an effective and personalized rehabilitative approach. Robotic rehabilitation offers new opportunities to improve clinical outcomes and the quality of life for patients. With further research and investment, this technology may become an integral part of treatment strategies for frozen shoulder, paving the way for a future where rehabilitation is more accessible, effective, and engaging.

Alternative Therapies

Whole-body cryotherapy (WBC) is a technique through which cold air at -110 °C to -140 °C is administered to a patient inside a chamber. It has been used for a myriad of conditions, such as fibromyalgia, rheumatoid arthritis, chronic back pain, osteoarthritis, and inflammatory arthritis, such as ankylosing spondylitis. WBC is believed to exert benefits through the release of β-endorphins, the reduction of afferent nerve pathways that modulate the sensation of pain, and anti-inflammatory effects. Some studies have compared the use of whole-body cryotherapy in conjunction with physiotherapy and passive joint mobilization with patients who received only physiotherapy and passive joint mobilization. At the end of the 4 weeks, patients who received WBC along with physiotherapy and mobilization showed better scores in pain reduction and ROM. Although the disability caused by AC can last for several months or years, symptoms may resolve spontaneously. Therefore, it is challenging to assess whether the patients included in this study, followed for only 4 weeks, benefited from the therapies or experienced a natural decrease in symptoms. Additionally, there was no control group to compare the interventions with the absence of therapy, but the authors believed it would have been unethical to include such a control, highlighting the difficulties in truly analyzing the effectiveness of WBC.

Jain et al. conducted a study to analyze the effects of

yoga therapy in addition to conventional methods (oral analgesics) for patients with AC. Patients were followed for a month; the results showed that yoga therapy did not improve symptoms based on the Shoulder Pain and Disability Index scores. Adherence to the yoga regimen was self-reported, so there was room for reporting errors in this study. Furthermore, all patients were chosen from Phase 1 of AC, which is known to be resistant to treatment. Therefore, a longer follow-up or patients in different phases of AC may have altered the results of yoga therapy.

VI SURGICAL TREATMENT FOR FROZEN SHOULDER

Surgical options for adhesive capsulitis include manipulation under anesthesia and arthroscopic capsular release. Manipulation is a technique performed under general anesthesia where the humerus is manipulated in an attempt to break adhesions. Moderate evidence suggests that manipulation alleviates pain and may improve the range of motion when followed by early physiotherapy. For patients with adhesive capsulitis who show minimal improvement in pain and cannot tolerate symptoms after six to twelve weeks of non-surgical treatment, a referral to an orthopedic surgeon may be considered [15].

Manipulation Under Anesthesia

Manipulation under anesthesia (MUA) is reserved for patients refractory to conservative and minimally invasive treatment options. MUA is based on aggressive manipulation of the shoulder joint, allowing for adhesions to be torn and the inferior capsule to be released. This forced rotation allows movements beyond a patient's normal pain threshold, which would otherwise be intolerable with regular physiotherapy. Many studies have demonstrated the remarkable effectiveness of MUA for AC, although its utility remains under debate. A recent 2018 study showed that MUA resulted in significant improvements in pain scores, range of motion, and patient satisfaction both at 3 weeks and 3 months. Additionally, a recent systematic review in 2019 indicated that considerable increases in range of motion and reductions in pain scores, leading to an 85% patient satisfaction rate, are possible with MUA. Due to the lack of a large randomized controlled trial, it is still not possible to argue for or against the use of MUA for adhesive capsulitis. The timing of when patients should receive MUA has also been debated. It was thought that early intervention could lead to overtreatment in a disease that may have mild progression. It was also believed that early intervention during the inflammatory phase of the disease would be less effective and would cause an increase in symptom recurrence. A retrospective study in 2015 showed that 6- 9 months after symptom onset may be the ideal time for intervention to prevent long-term complications and overtreatment. A 2017 study demonstrated that patients who had limited success with MUA should be offered a repeat MUA. Subsequent MUA led to a significant reduction in pain scores and an increase in range of motion. While considered a safe procedure, MUA is not without its intrinsic risks. There have been cases of capsular tearing, labrum detachment, hemarthrosis, glenoid/humeral fractures, as well as the risk associated with anesthesia. Vastamaki et al. reported that MUA in diabetic patients may be less effective than in non- diabetic patients. Various studies have also compared the utility of MUA with other more conservative methods. Jacobs et al. conducted a randomized controlled trial, finding no difference between MUA and intra-articular steroid injections in terms of pain reduction or increased range of motion. Furthermore, a 2007 randomized controlled trial showed that comparing regular physiotherapy exercises with MUA showed no difference at 3, 6, and 12 months. MUA has demonstrated utility and proven effectiveness for the treatment of AC; however, given the lack of large randomized controlled studies, its use should be limited only when more conservative measures have failed.

Arthroscopic Capsulotomy

Arthroscopic capsular release (ACR) is a safe and effective modality in the treatment of AC. Compared to other treatment methods, arthroscopic release can offer distinctive advantages. Direct visualization of the affected joint allows for diagnostic confirmation and exclusion of additional pathologies [12]. The effectiveness of capsular release has been demonstrated in a variety of studies with dramatic reductions in pain scores, increased range of motion, and overall improvement in shoulder function. There is some debate about which technique and approach provides the best relief for patients. Most authors have published data where the contracted CHL ligament and the rotator cuff interval have been released. The anterior-inferior capsular release approach has been performed quite frequently with good results. Posterior release remains controversial. It is thought that additional posterior release allows for greater internal rotation of the shoulder. Although this has been demonstrated in various studies, when comparing long-term follow-ups with anterior release, there was no difference in range of motion between patients with isolated anterior release. Furthermore, complete circumferential release of the capsule is associated with a higher risk of axillary nerve injury. Currently, there is no consensus regarding the extent of capsular release or which structures should be isolated. ACR is effective in

both diabetic and non- diabetic patients. Diabetic patients have shown poorer improvement in internal rotation and forward flexion. Although potentially beneficial, ACR carries intrinsic risks. Postoperative capsular adhesion can be a significant complication after ACR. There is a delicate balance between post-operative immobilization to allow healing and early mobilization to prevent arthrofibrosis. It is currently believed that the best treatment to prevent postoperative capsular adhesion is adequate pain control to facilitate early mobilization. ACR has proven to be an effective treatment for adhesive capsulitis and may be considered in patients refractory to more conservative treatments.

Hydrokinesitherapy: Post-Operative Recovery

Hydrokinesitherapy is a therapeutic discipline that combines the properties of water with physiokinesitherapy exercises, playing a fundamental role in the post-operative recovery process. This rehabilitative approach is particularly effective for patients who have undergone orthopedic, neurological surgeries, or sports injuries, as it leverages the benefits of water to facilitate movement, reduce pain, and improve functionality [14].

Hydrokinesitherapy is based on the principle that water provides an ideal environment for physical exercise. Thanks to its density, water provides support that reduces the load on joints and muscles, allowing patients to perform movements that may be painful or impossible to achieve on land. During hydrokinesitherapy sessions, patients can work on strength, endurance, flexibility, and coordination in a controlled and safe context.

Post-operative recovery is a critical period during which the body must adapt and heal after surgery. Hydrokinesitherapy offers numerous advantages in this context:

- Pain Reduction: Warm water has a relaxing effect on muscles and joints, helping to reduce the perception of pain. This is particularly useful in the early stages of recovery when the patient may be limited in movements due to pain.
- Improved Mobility: The absence of gravity in water allows patients to move more freely, facilitating the regaining of joint mobility. Water exercises help restore the range of motion of joints without the risk of further injury.
- Muscle Strengthening: Water provides natural resistance, allowing patients to perform muscle- strengthening exercises more effectively and safely. This strengthening is essential for regaining muscle strength lost during the post-operative immobilization period.
- Improved Circulation: Exercising in water stimulates blood circulation, helping to reduce the risk of complications such as deep vein thrombosis, which can occur after surgery.
- Motivation and Psychological Well-Being: The aquatic environment is often perceived as more pleasant and relaxing compared to a traditional gym. This can increase patients' motivation to actively participate in their recovery program, thus contributing to better outcomes.

V CONCLUSION

Hydrokinesitherapy represents an innovative and highly effective approach for post-operative recovery. Due to its multiple physical and psychological benefits, it offers patients a way to regain functionality and improve quality of life. With the continuous development of rehabilitation technologies and techniques, hydrokinesitherapy confirms itself as a valuable tool in the landscape of modern physiotherapy, promoting a faster and safer recovery. Collaboration between physiotherapists, doctors, and patients is essential to maximize results and ensure optimal recovery.

Adhesive capsulitis, commonly known as "frozen shoulder," represents a complex and multifactorial condition that can significantly compromise shoulder joint functionality. Through the analysis of rehabilitative aspects, it has emerged that an integrated approach, combining manual treatments and surgical interventions, can optimize clinical outcomes and enhance patients' quality of life.

Manual treatments, such as joint mobilization and manual therapy techniques, have proven effective in reducing pain and improving joint mobility in the early stages of adhesive capsulitis. These approaches, when performed by experienced professionals, can help prevent the onset of stiffness and facilitate functional recovery.

However, in cases where adhesive capsulitis does not adequately respond to conservative therapy, it is essential to consider surgical options. Arthroscopy, in particular, has shown promising results in restoring joint mobility and reducing pain, offering patients an effective option to address persistent functional limitations.

In conclusion, managing adhesive capsulitis requires a personalized approach that takes into account the specific needs of the patient and the phase of the pathology. The synergy between manual treatments and surgical interventions can lead to optimal recovery, improving not only shoulder functionality but also the psychological and social well-being of the patient. Further research is desirable to deepen rehabilitative strategies and define standardized protocols that can guide professionals in

managing this condition.

CONFLICT OF INTEREST

The author declares no conflict of interest. AUTHOR CONTRIBUTION Roberto Grisiglione conceptualized, researched, and wrote the entire manuscript under academic supervision. All literature sources and analyses are derived from his original thesis, “REHABILITATIVE ASPECTS OF ADHESIVE CAPSULITIS: FROM MANUAL TREATMENT TO SURGICAL INTERVENTION (comparison and effectiveness of each treatment)”.

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