CASE REPORT

Advanced Physiotherapy Approach using X-sens Gait Motion Analysis for the Management of Adhesive Capsulitis- A case report

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ABSTRACT

Background: Adhesive capsulitis, commonly known as frozen shoulder, is a debilitating condition in which the pain and stiffness progressively worsen, restricting the motion of the shoulder joint, with functional limitation. Advanced technologies, such as Xsens Gait Motion Analysis , can be used for real-time 3D motion capture, making them very helpful for the precise assessment and management of musculoskeletal disorders.

Case summary: A 43-year-old male with a two-month history of localized pain in the anterior and lateral aspects of the right shoulder reported difficulty with overhead activities and functional tasks. He had decreased active and passive ranges of motion in shoulder flexion and abduction. The initial clinical examination indicated adhesive capsulitis. Detailed kinematic data with specific movement deficits were identified by using Xsens inertial sensors. Based on the study, a structured physiotherapy program was designed, encompassing manual therapy, stretching exercises, and progressive strengthening exercises. Progress was monitored through regular follow-ups, and interventions were adjusted as needed.

Outcome measures: NPRS – Numerical Pain Rating Scale, SPADI- Shoulder pain and disability index, DASH - Disability of Arm, Shoulder, and Hand Questionnaire are the outcome measures used.

Conclusion: Following a 6-week intervention, there was a significant improvement in pain reduction, accompanied by an increase in shoulder range of motion (ROM) and functional capacity in the patient. Motion analysis using Xsens demonstrated a measurable improvement, with a 50% increase in shoulder flexion and abduction, enabling the patient to resume their daily activities. This case demonstrates the value of Xsens inertial sensor technology in enhancing diagnostic precision and guiding proper treatment strategies for adhesive capsulitis, a step toward improved patient outcomes in musculoskeletal rehabilitation.

Keywords: Adhesive capsulitis, frozen shoulder, X-sens Gait motion Analysis, Functional Recovery, rehabilitation.

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INTRODUCTION

Adhesive capsulitis, commonly referred to as frozen shoulder, represents a pathological state characterized by the gradual emergence of discomfort and rigidity within the shoulder joint, culminating in a significant limitation of its mobility [1]. This disorder is said to exist in nearly 2-5 per cent of the entire population. It is predominantly reported to occur in adults aged 40 to 60, more commonly in females than in males [2]. The symptoms of adhesive capsulitis typically evolve in three stages: the painful stage is characteristically marked by severe pain and loss of mobility; the adhesive phase is characterised by progressive worsening of stiffness due to a thickening and tightening of the joint capsule; and thawing is when pain is relieved, but the stiffness remains, though this resolves over time [3]. Certain risk factors have been identified in the development of adhesive capsulitis. These include chronic inflammatory processes, endocrine or metabolic disorders, diabetes mellitus, neurological disturbances, as well as prolonged periods of post-operative immobilisation in surgery [4]. Adhesive capsulitis poses physical challenges and significantly impacts daily activities and quality of life [5]. Primary or idiopathic adhesive capsulitis is characterised by a slow onset of pain and stiffness in the glenohumeral joint without any cause for it to be determined [6]. Various predisposing factors have been recognised as contributing to secondary adhesive capsulitis. Review studies have categorised these secondary factors into three distinct groups based on their characteristics: systemic, intrinsic, and extrinsic components [7]. Diabetes mellitus, thyroid issues, and hypoadrenalism are examples of systemic causes [8]. Intrinsic factors encompass issues like biceps tendinitis, calcific tendinitis, acromioclavicular arthritis, and rotator cuff diseases. In contrast, extrinsic factors involve cardiovascular problems, Parkinson's disease, cervical disc disease, cerebrovascular accidents, and humeral fractures [9].

Xsens Gait Motion Analysis is the world's leading provider of 3D motion analysis technology, offering inertial motion capture solutions. It offers wearable technology, such as motion capture suits and trackers, featuring compact, lightweight sensors that record body movement and orientation information. All the sensors function wirelessly to achieve motion capture in diverse settings. Xsens technology encompasses various fields, including biomechanics, sports science, healthcare, and entertainment, enabling researchers, clinicians, and practitioners to gain an accurate and practical understanding of human movement dynamics [10]. Rehabilitation methodologies have undergone an impressive evolution with the integration of inertial sensor technology, as exemplified by X-Sens. In this regard, sensors enable the very accurate and objective tracking of joint movement, muscle activation patterns, and overall functionality during exercises. The accuracy and personalisation of the rehabilitation programs are improved because X-Sens technology provides immediate feedback and quantified information [11]. The study outlines the patient's condition, the progression of their rehabilitation, and the outcomes achieved. It also underscores the potential of X-Sens technology in optimising patient results and rehabilitation strategies. This case study aims to demonstrate the benefits and effectiveness of inertial sensor technology in treating adhesive capsulitis.

Patient information

We report a case of a 43-year-old male patient who sought assistance in the physiotherapy department. His complaint had been about pains in the anterior and lateral regions of the right shoulder joint, as well as the inability to perform overhead movements involving the right shoulder, for the past two months. Of importance, there is a medical history associated with the patient's diabetes mellitus condition, which he has maintained for the last 10 years.

Physical Exam

The patient's consent was obtained before the examination. On physical examination, typical vital signs were noted, including a body temperature of 37 °C, a pulse rate of 78 beats per minute, a respiratory rate of 22 breaths per minute, and a blood pressure of 110/80 mmHg. The pain is intermittent and gradually progressive at night, with tenderness of grade 1 present over the anterior and lateral aspects of the shoulder joint. The right arm swing is reduced, and the patient is unable to perform basic activities of daily living. Crepitus and joint stiffness were present during both active and passive movement. Table 1: The range of motion of the right shoulder joint measured using goniometry, and Table 2: The strength of the right shoulder assessed using manual muscle testing grading.

Sr.no	Movement	Active range of motion	Passive range of motion
1	Shoulder flexion	0-125°	0-130°
2	Shoulder extension	0-40°	0-45°
3	Shoulder abduction	0-100°	0-105°
4	Shoulder adduction	100-0°	105-0°
5	Medial rotation	0-65°	0-70°
6	Lateral rotation	0-55°	0-60°

Table 1. Range of motion (ROM) of the right side

Sr.no	Movement	Grade
1	Shoulder flexor	2/5
2	Shoulder extensor	2/5
3	Shoulder abductor	2/5
4	Shoulder adductor	4/5
5	Shoulder internal rotation	4/5
6	Shoulder external rotation	2/5
7	Elbow flexor	5/5
8	Elbow extensor	5/5
9	Pronator	5/5
10	Supinator	5/5
11	Wrist flexor	5/5
12	Wrist extensor	5/5

13	Ulnar deviatiors	5/5
14	Radial deviators	5/5

Table 2. Manual muscle testing (MMT) of the Right side.

Diagnostic assessment

The patient's magnetic resonance imaging (MRI) scan reveals heterogeneous hyperintensity in the glenohumeral ligament, consistent with adhesive capsulitis.

Intervention

Following the assessment, the patient received therapeutic interventions, as outlined in Table 3. The X-sens Gait Motion Analysis guided these intervention results, improving the outcomes as measured and presented in Figures 1 and 2.

Sr No	Treatment	Description	Intensity
1	Phase I (1st - 2nd week): Biofeedback is introduced via Xsens to enhance awareness and control.		
	Patient Education	Explain the nature of adhesive capsulitis and set realistic expectations for the rehabilitation process.	NA
	Pain Management	Modalities such as ice or heat are used to manage pain and inflammation.	Before and after the Rehab Programme for 10 minutes
	Gentle Range of Motion Exercises	Passive range of motion exercises to maintain flexibility without exacerbating pain, Pendulum exercises, and gentle stretching.	10 reps for three sets
	PRE (progressive resistive exercise)	Based on their tolerance, the individual is instructed to engage in forward and lateral wall climbing up to 180 degrees four times per day. They are encouraged to perform passive or active external rotation, reaching 40 degrees at the side and 90 degrees in abduction, gradually progressing towards achieving the range of motion on the unaffected side.	
2	Phase II (2nd to 4th week) Biofeedback is introduced via Xsens to enhance awareness and control.		
	Pain Management	Modalities such as ice or heat may be used to manage pain and inflammation.	Before and after the Rehab Programme
	Strengthening exercises	If these motions are accomplished, the rehabilitation program can include the initiation of strengthening exercises using 1-2 pounds. Activities such as shoulder shrug, range of motion retraining, and postural retraining are recommended, with caution against passive stretching beyond specified limits. The rehabilitation plan progresses to deltoid strengthening using elastic tubing, TheraBand, free weights, and exercises involving wall pulleys. Peri-scapular, deltoid, biceps, and triceps strengthening exercises are introduced using elastic tubing, free weights, and wall pulleys, emphasizing posture, scapular stabilization (protraction, retraction, and elevation), and muscular endurance.	10 reps for 3 sets
	Mobilization	Maitland Mobilization: Performing Maitland Mobilization techniques for adhesive capsulitis involves a systematic and graded approach to joint mobilisation according to the stage of adhesive capsulitis: 1. Assessment: Begin with a thorough assessment of the shoulder joint, considering any limitations in range of motion, pain levels, and specific restrictions in movement. 2. Patient Positioning: Place the patient comfortably, typically sitting or lying down, allowing access to the shoulder joint. 3. Stabilization: Stabilize the scapula to isolate movement at the glenohumeral joint. 4. Grade I and II Mobilization: • For initial stages or when the patient is highly sensitive, use gentle oscillatory movements within the pain-free range (Grade I and II mobilisations). • This may involve rhythmic oscillations with minimal force, focusing on the direction that aims to improve the specific limitation observed in the patient. 5. Grade III and IV Mobilization: • As tolerance improves, progress to higher grades of mobilisation (Grade III and IV). • Grade III involves more significant amplitude oscillations, and Grade IV includes more minor amplitude movement at the end of the available range. • Carefully monitor the patient's response and adjust the force and direction accordingly. 6. Accessory Movements: • Introduce accessory movements to address joint play and specific joint restrictions. • This might involve distraction, gliding, or rotational movements to improve the overall joint function.	10 reps for 3 sets
3	Phase III (4 to 6 weeks) Biofeedback is introduced via Xsens to enhance awareness and control.		
	Progressive Strengthening	Continue strengthening exercises with increased resistance, focusing on eccentric strengthening to enhance control.	10 reps for five sets
	Neuromuscular Control	Proprioceptive exercises to improve neuromuscular control and joint stability.	10 reps for five sets
	Home exercise programme	Providing a home exercise program for ongoing maintenance and emphasising the importance of regular stretching and strengthening exercises.	NA
	Lifestyle and Ergonomic Advice	Educating on proper body mechanics and ergonomics to prevent reoccurrence and encouraging maintaining a healthy lifestyle to support joint health.	NA

Table 3: Therapeutic Intervention of the Patient

Figure 1: Patient performing Movements after being applied by a sensor.

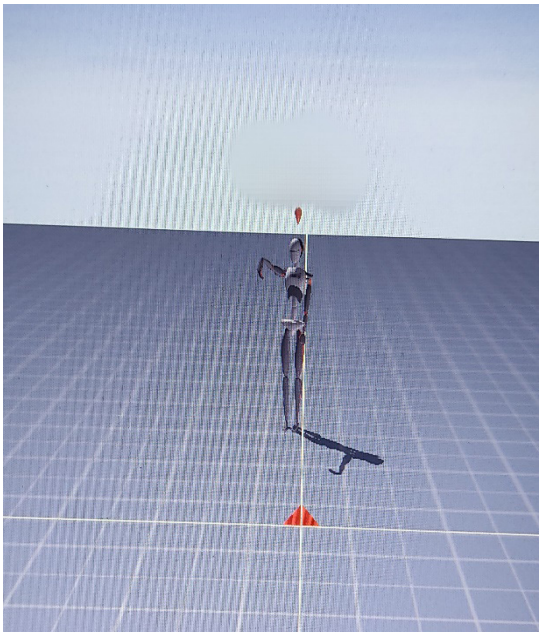

Figure 2: X-sens inertial sensor technology-based training to enhance awareness and control of the movement.

Follow-up and Outcomes

Table 4-6 presents the outcomes recorded after the intervention.

Sr.no	Movement	Active range of motion	Passive range of motion
1	Shoulder flexion	0-145°	0-150°
2	Shoulder extension	0-60°	0-65°
3	Shoulder abduction	0-120°	0-125°
4	Shoulder adduction	120-0°	125-0°
5	Medial rotation	0-65°	0-70°
6	Lateral rotation	0-55°	0-60°

Table 4. Post-intervention ROM of the right side

Sr.no	Movement	Grade
1	Shoulder flexor	4/5
2	Shoulder extensor	4/5
3	Shoulder abductor	4/5
4	Shoulder adductor	4/5
5	Shoulder internal rotation	4/5
6	Shoulder external rotation	4/5
7	Elbow flexor	5/5
8	Elbow extensor	5/5
9	Pronators	5/5
10	Supinators	5/5
11	Wrist flexor	5/5
12	Wrist extensor	5/5
13	Ulnar deviators	5/5
14	Radial deviators	5/5

Table 5: Post-intervention MMT of the right side

Sr no	Scales that are used as outcome measures	Score pre-intervention	Score post-intervention
1	NPRS	7 – severe pain	2- mild pain
2	SPADE	61 – very severe shoulder pain and disability	20 – mild shoulder pain and disability
3	DASH	60/100	42/100

Table 6. Outcome Measures taken post-intervention

NPRS – Numerical Pain Rating Scale
SPADI- Shoulder pain and disability index
DASH - Disability of Arm, Shoulder, and Hand Questionnaire

DISCUSSION

In this study, we utilize inertial sensor technology, specifically x-sens, to enhance the efficacy of adhesive capsulitis rehabilitation by integrating kinematic analysis and real-time feedback. This approach offers a technologically advanced and personalized solution to improve patient outcomes and facilitate a faster prognosis for a 53-year-old male with adhesive capsulitis. The rehabilitation program is introduced to patients in three phases, targeting pain management, range of motion exercises, strengthening exercises, mobilization, and neuromuscular control, followed by a home program.

X-Sens inertial sensors are used in rehabilitation to measure mobility by capturing real-time motion data. From these data, one can obtain substantial information about a subject's functional movement pattern, joint stability, and range of motion- a way to modify the rehabilitation program based on tangible evidence [12] tremendous technological advances have emerged in human motion analysis (HMA. The technology promotes the development of individualised treatment plans specially designed for each patient's particular movement patterns and biomechanics, hence optimising therapy results and

minimising re-injury risks [10]. Real-time feedback on the patient's movement quality, alignment, and biomechanics during the session will help monitor their progress more effectively and make adjustments promptly. Monitoring activity outside the clinic enhances adherence to exercise regimes and activity changes, increasing rehabilitation strength [13]. In addition to more traditional practices like gait analysis or manual muscle testing, the X-Sens sensors provide a comprehensive assessment of the patient's status and progress; therefore, clinicians have a better chance of crafting treatment plans that precisely target specific needs. This can only be met with a rehabilitation program of cryotherapy, stretching, isotonic training, mobilisation, and resistance training that could provide better joint mobility, muscle strength, pain relief, and restoration of functions [14]. I Selviani (2023) demonstrated that the Codman Pendular Exercise helps to preserve soft tissue flexibility, increasing the range of motion within the shoulder joint and reducing discomfort [15]against the provision of codman pendular exercise and scapular mobilization in frozen shoulder conditions for 4 weeks. Results: Analysis of pain loss difference test with visual analoge scale (vas.

CONCLUSION

This case report demonstrates the utility of a standardised physiotherapy protocol incorporating X-Sens inertial sensor technology in assisting a patient with adhesive capsulitis to reach a positive rehabilitation outcome. Substantial gains were achieved in pain relief, range of motion, muscle strength, and functional ability through a collaborative, multidisciplinary approach. This study underlines the worth of early intervention, multifaceted cooperation, and integrating technological tools in managing adhesive capsulitis. It points to the success of physiotherapy enhanced with X-Sens technology in improving patient outcomes.

Declaration

Consent for publication: Informed consent was obtained from the patient to publish the case report. The patient was told that their identity would remain confidential.

Ethics approval and consent to participate: As it is a case report, no approval is needed. The patient provides written informed consent to participate.

Availability of data and materials: No

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