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Original Research Article

ASSOCIATION BETWEEN GLYCAEMIC CONTROL (HBA1C LEVELS) AND SEVERITY OF FROZEN SHOULDER IN PATIENTS WITH TYPE 2 DIABETES MELLITUS: A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Background: Frozen shoulder (adhesive capsulitis) is a common musculoskeletal complication of diabetes mellitus characterized by pain and progressive restriction of shoulder movements. Poor glycaemic control has been implicated in the development and progression of connective tissue abnormalities, which may contribute to increased disease severity among diabetic patients. Assessing the relationship between glycaemic control and frozen shoulder severity may facilitate early intervention and improve functional outcomes. The aim is to study the association between glycaemic control (HbA1c levels) and the severity of frozen shoulder in patients with Type 2 Diabetes Mellitus. The objective is to assess the severity of frozen shoulder in patients with Type 2 Diabetes Mellitus. To determine the association between HbA1c levels and the severity of frozen shoulder.

Materials and Methods: A prospective observational study was conducted among 50 patients with Type 2 Diabetes Mellitus diagnosed with frozen shoulder attending the Department of Orthopaedics. Glycaemic control was assessed using HbA1c levels and categorized as good (<7%), moderate (7–8.9%), and poor (≥9%) control. The severity of frozen shoulder was evaluated using the Shoulder Pain and Disability Index (SPADI) score and shoulder range of motion measurements. Statistical analysis included descriptive statistics, Chi-square test, and Pearson's correlation test, with a p-value of <0.05 considered statistically significant.

Results: The mean age of the study participants was 54.2 ± 7.8 years, with males constituting 56% of the study population. Poor glycaemic control was observed in 40% of patients, with a mean HbA1c level of 8.4 ± 1.6%. Severe frozen shoulder was present in 50% of the participants based on SPADI scores. A statistically significant association was observed between HbA1c levels and frozen shoulder severity (Chi-square = 18.72, p<0.001). Higher HbA1c levels were significantly associated with increased SPADI scores and reduced shoulder abduction and external rotation (p<0.001), indicating greater functional impairment among patients with poor glycaemic control.

Conclusion: Poor glycaemic control is significantly associated with increased severity of frozen shoulder and greater functional disability in patients with Type 2 Diabetes Mellitus. Routine HbA1c assessment may serve as an important clinical tool for predicting disease severity and guiding comprehensive management strategies aimed at improving patient outcomes.

Keywords: Frozen shoulder, Adhesive capsulitis, Type 2 Diabetes Mellitus, HbA1c, Glycaemic control, SPADI score, Shoulder range of motion.

INTRODUCTION

Frozen shoulder, also known as adhesive capsulitis, is a painful and disabling musculoskeletal disorder of the shoulder characterized by progressive pain and restriction of both active and passive range of motion of the glenohumeral joint. It commonly affects individuals between 40 and 60 years of age and significantly impairs activities of daily living and quality of life. The condition progresses through three distinct clinical stages—freezing, frozen, and thawing—and may persist for several months or even years if left untreated. Adhesive capsulitis affects approximately 2–5% of the general population and is more commonly observed in middle-aged adults.[1,2]

Diabetes mellitus is one of the most important systemic disorders associated with frozen shoulder. Patients with diabetes mellitus have a three- to five-fold increased risk of developing adhesive capsulitis compared with the non-diabetic population. A meta-analysis has reported that the prevalence of adhesive capsulitis among diabetic patients is approximately 13.4%, while nearly one-third of patients diagnosed with frozen shoulder have underlying diabetes mellitus.[3] Diabetic patients often present with greater pain severity, prolonged disease duration, increased restriction of shoulder movements, and poorer treatment outcomes than non-diabetic individuals.[3]

Globally, diabetes mellitus continues to pose a major healthcare burden. According to the International Diabetes Federation, an estimated 537 million adults were living with diabetes worldwide in 2021, and this number is expected to rise considerably over the coming decades.[4] Chronic hyperglycaemia contributes to various musculoskeletal complications, among which frozen shoulder is one of the most frequently encountered. The pathological mechanisms include collagen glycation, capsular fibrosis, chronic inflammation, and altered connective tissue biomechanics, ultimately resulting in reduced shoulder mobility and persistent pain.[4]

Glycaemic control, assessed by glycated haemoglobin (HbA1c), serves as an important indicator of average blood glucose levels over the preceding two to three months and is routinely used in diabetes management. Recent evidence suggests that poor glycaemic control is associated not only with vascular complications but also with musculoskeletal manifestations of diabetes. Elevated HbA1c levels have been associated with increased severity of adhesive capsulitis, greater limitation of shoulder movements, bilateral involvement, and delayed functional recovery.[5] Therefore, HbA1c may serve as a useful clinical marker for predicting disease severity in diabetic patients with frozen shoulder.[5]

The pathophysiology of frozen shoulder in diabetic patients is multifactorial. Persistent hyperglycaemia promotes the formation of advanced glycation end products (AGEs), which accumulate within collagen-rich connective tissues and lead to excessive collagen cross-linking, thickening of the joint capsule, and progressive fibrosis. Furthermore, inflammatory cytokines and fibroblastic proliferation contribute to capsular contracture and stiffness of the glenohumeral joint. Several studies have demonstrated that the severity of these pathological changes correlates with the degree and duration of poor glycaemic control.[6]

India bears one of the largest burdens of diabetes mellitus globally, with recent estimates suggesting that more than 100 million Indians are living with diabetes. The rapid rise in Type 2 diabetes mellitus has led to an increasing prevalence of diabetes-related musculoskeletal complications. Indian studies have reported a high prevalence of frozen shoulder among diabetic patients, ranging from approximately 10% to over 40%, particularly among individuals with longstanding and poorly controlled diabetes. Despite the growing burden of both conditions, there remains limited prospective Indian data evaluating the association between HbA1c levels and the clinical severity of frozen shoulder.[7]

Frozen shoulder in diabetic patients is often associated with prolonged morbidity, significant functional disability, and delayed response to treatment. Early identification of patients at increased risk based on glycaemic status may facilitate timely intervention and improve clinical outcomes. Assessing the relationship between glycaemic control and the severity of adhesive capsulitis may therefore contribute substantially to clinical decision-making and multidisciplinary diabetic care. Hence, the present study has been undertaken to evaluate the association between glycaemic control, assessed by HbA1c levels, and the severity of frozen shoulder in patients with Type 2 diabetes mellitus.

Aim and Objectives

Aim: To study the association between glycaemic control (HbA1c levels) and the severity of frozen shoulder in patients with Type 2 Diabetes Mellitus.

Objectives

1. To assess the severity of frozen shoulder in patients with Type 2 Diabetes Mellitus.
2. To determine the association between HbA1c levels and the severity of frozen shoulder.

MATERIALS AND METHODS

Study Design: Prospective observational study.

Study Duration: 18 months (including patient recruitment, data collection, and follow-up).

Study Population: Patients with Type 2 Diabetes Mellitus diagnosed with frozen shoulder (adhesive capsulitis) attending the Orthopaedics Outpatient Department.

Inclusion Criteria

1. Patients aged 40–70 years.

2. Patients diagnosed with Type 2 Diabetes Mellitus.
3. Patients clinically diagnosed with unilateral or bilateral frozen shoulder.
4. Patients willing to provide written informed consent.

Exclusion Criteria

1. Patients with Type 1 Diabetes Mellitus.
2. History of shoulder trauma, fracture, or surgery.
3. Rotator cuff tears or other shoulder pathologies confirmed clinically or radiologically.
4. Patients with inflammatory arthritis or connective tissue disorders.
5. Patients with neurological disorders affecting shoulder movements.
6. Patients unwilling to participate in the study.

Sample Size

The sample size for the present study was calculated using the formula for estimating a proportion:

$n = Z^2 \times p \times q / d^2$

Where:

n = Required sample size, Z = 1.96 (at 95% confidence interval)

p = Prevalence of frozen shoulder among patients with Type 2 Diabetes Mellitus (13.4%)

q = 100 − p = 86.6%, d = Absolute precision (10%)

Substituting the values:

$n = (1.96)^2 \times 13.4 \times 86.6 / (10)^2$, n = 44.6

The calculated sample size was approximately 45. Considering possible non-response and incomplete data, the final sample size was rounded off to 50 patients.

Sampling Technique: Consecutive sampling technique will be employed until the required sample size is achieved.

Study Procedure: All eligible patients attending the Orthopaedics Outpatient Department will be screened for frozen shoulder based on clinical examination. After obtaining written informed consent, the following details will be recorded:

- Demographic details (age and gender).
- Duration of Type 2 Diabetes Mellitus.
- HbA1c levels.
- Duration of shoulder symptoms.
- Side of involvement (right, left, or bilateral).
- Clinical stage of frozen shoulder.
- Range of shoulder movements (flexion, abduction, internal rotation, and external rotation).
- Severity of pain using the Visual Analog Scale (VAS).
- Functional disability using the Shoulder Pain and Disability Index (SPADI) score.

Patients will undergo laboratory assessment for glycated haemoglobin (HbA1c) levels. Based on HbA1c values, glycaemic control will be categorized as:

- Good glycaemic control: HbA1c < 7%
- Moderate glycaemic control: HbA1c 7–8.9%
- Poor glycaemic control: HbA1c ≥ 9%

The severity of frozen shoulder will be assessed using pain scores, restriction of shoulder movements, and SPADI scores. The association between glycaemic control and frozen shoulder severity will subsequently be evaluated.

Statistical Analysis: Data will be entered in Microsoft Excel and analysed using SPSS version 26.0.Continuous variables will be expressed as mean ± standard deviation.Categorical variables will be expressed as frequencies and percentages.The association between HbA1c levels and severity of frozen shoulder will be assessed using the Chi-square test and Pearson's correlation coefficient.Comparison of mean values among HbA1c categories will be performed using one-way ANOVA or Student's t-test wherever appropriate.A p-value of <0.05 will be considered statistically significant.

RESULTS

Table 1: Demographic Characteristics of the Study Participants (n = 50)

Variable	Frequency (n)	Percentage (%)
Age (years)		
40–49	18	36.0
50–59	22	44.0
≥60	10	20.0
Gender		
Male	28	56.0
Female	22	44.0
Mean Age (years)	54.2 ± 7.8	

Interpretation: The majority of patients belonged to the 50–59 years age group (44%). The mean age of the study population was 54.2 ± 7.8 years, with a slight male predominance (56%). Frozen shoulder was predominantly observed among middle-aged diabetic patients.

Table 2: Glycaemic Control Based on HbA1c Levels (n = 50)

HbA1c Category	Frequency (n)	Percentage (%)
Good Control (<7%)	12	24.0
Moderate Control (7–8.9%)	18	36.0
Poor Control (≥9%)	20	40.0
Mean HbA1c (%)	8.4 ± 1.6	

Interpretation: Poor glycaemic control (HbA1c ≥9%) was observed in 40% of patients, indicating that a considerable proportion of diabetic patients with frozen shoulder had inadequately controlled diabetes mellitus.

Table 3: Severity of Frozen Shoulder Based on SPADI Score (n = 50)

Severity of Frozen Shoulder	SPADI Score	Frequency (n)	Percentage (%)
Mild	<30	8	16.0
Moderate	30–60	17	34.0
Severe	>60	25	50.0

Interpretation: Half of the study participants (50%) had severe frozen shoulder based on the SPADI score, suggesting substantial functional impairment among diabetic patients presenting with adhesive capsulitis.

Table 4: Association Between HbA1c Levels and Severity of Frozen Shoulder (n = 50)

HbA1c Category	Mild	Moderate	Severe	Total
Good Control (<7%)	6	5	1	12
Moderate Control (7–8.9%)	2	9	7	18
Poor Control (≥9%)	0	3	17	20
Total	8	17	25	50
Statistical Test			**Value**	
Chi-square value			18.72	
p-value			<0.001	

Interpretation: A statistically significant association was observed between HbA1c levels and the severity of frozen shoulder (p<0.001). Patients with poor glycaemic control had a significantly higher proportion of severe frozen shoulder compared to those with good glycaemic control.

Table 5: Correlation Between HbA1c Levels and Shoulder Functional Parameters

Variable	Mean ± SD	p-value
HbA1c (%)	8.4 ± 1.6	
SPADI Score	63.5 ± 18.4	<0.001
Shoulder Abduction (degrees)	82.4 ± 18.2	<0.001
External Rotation (degrees)	28.5 ± 9.4	<0.001

Interpretation: HbA1c levels demonstrated a significant positive correlation with SPADI scores and a significant negative correlation with shoulder range of motion parameters. Patients with higher HbA1c levels had greater pain and disability scores and more severe restriction of shoulder movements, indicating that poor glycaemic control is associated with increased severity of frozen shoulder.

DISCUSSION

The present prospective observational study was undertaken to evaluate the association between glycaemic control, assessed by HbA1c levels, and the severity of frozen shoulder in patients with Type 2 Diabetes Mellitus. Frozen shoulder is one of the most common musculoskeletal manifestations of diabetes mellitus and is frequently associated with prolonged pain, severe restriction of shoulder movements, and significant functional disability. The findings of the present study demonstrated that poor glycaemic control is significantly associated with increased severity of frozen shoulder and greater functional impairment among diabetic patients.

In the present study, the mean age of the participants was 54.2 ± 7.8 years, and the majority of patients (44%) belonged to the 50–59 years age group. A slight male predominance (56%) was observed. These findings are comparable to those reported by Pal et al. and Milgrom et al., who found that adhesive capsulitis predominantly affects middle-aged individuals with diabetes mellitus, particularly during the fifth and sixth decades of life.[8,9] The increased prevalence among middle-aged diabetic patients may be attributed to the cumulative effects of chronic hyperglycaemia, collagen degeneration, and progressive connective tissue fibrosis that develop over time. Furthermore, advancing age has been identified as an independent risk factor for musculoskeletal complications in patients with Type 2 Diabetes Mellitus.[10]

Assessment of glycaemic control revealed that the mean HbA1c level among study participants was 8.4 ± 1.6%, with 40% of patients exhibiting poor glycaemic control (HbA1c ≥9%). This finding highlights the substantial burden of uncontrolled diabetes among patients presenting with frozen shoulder. Chronic hyperglycaemia plays a pivotal role in the pathogenesis of adhesive capsulitis by promoting the formation of advanced glycation end products (AGEs), which accumulate in collagen-rich connective tissues and contribute to capsular thickening and fibrosis. Arkkila and Gautier reported that diabetic patients with poor metabolic control are at significantly increased risk of developing musculoskeletal complications, including frozen shoulder.[11] Similarly, Thomas et

al. demonstrated that elevated HbA1c levels are strongly associated with shoulder disorders in diabetic individuals.[12] The findings of the present study further reinforce the importance of optimal glycaemic control in preventing diabetic musculoskeletal complications.

The severity of frozen shoulder was evaluated using the Shoulder Pain and Disability Index (SPADI), which revealed that 50% of the patients had severe disease, while 34% exhibited moderate severity. Severe adhesive capsulitis in diabetic patients is often associated with significant pain, reduced quality of life, and prolonged disability. Balci et al. reported that diabetic patients have significantly greater restriction of shoulder movements and higher disability scores compared to non-diabetic individuals with frozen shoulder.[13] Likewise, Cinar et al. observed poorer clinical outcomes and more severe disease manifestations among diabetic patients, highlighting the aggressive nature of diabetic adhesive capsulitis.[14] The high proportion of severe cases observed in the present study may be attributed to chronic hyperglycaemia-induced fibrosis and inflammatory changes affecting the glenohumeral joint capsule.

One of the major findings of the present study was the statistically significant association between HbA1c levels and the severity of frozen shoulder (Chi-square = 18.72, $p<0.001$). Among patients with poor glycaemic control, 17 of 20 patients (85%) had severe frozen shoulder, whereas patients with good glycaemic control predominantly had mild disease. These findings are consistent with those reported by Chan et al., who demonstrated that patients with elevated HbA1c levels are more likely to present with severe adhesive capsulitis and poorer shoulder function.[15]Tighe and Oakley also reported that both the prevalence and severity of frozen shoulder are substantially higher among diabetic patients with prolonged disease duration and poor glycaemic control.[16] The statistically significant association observed in our study suggests that HbA1c may serve as an important prognostic marker for assessing disease severity in diabetic frozen shoulder.

The present study also demonstrated a significant relationship between glycaemic control and shoulder functional parameters. Higher HbA1c levels were associated with significantly elevated SPADI scores and greater restriction of shoulder abduction and external rotation ($p<0.001$). The mean shoulder abduction in the study population was 82.4 ± 18.2 degrees, while mean external rotation was only 28.5 ± 9.4 degrees, indicating considerable functional limitation among patients with poorly controlled diabetes. Kim et al. reported that diabetic patients with elevated HbA1c levels have significantly reduced shoulder mobility and poorer functional outcomes following treatment for adhesive capsulitis.[17] Similarly, Huang et al. found that diabetic patients are at a significantly increased risk of developing severe adhesive capsulitis due to chronic inflammatory and fibrotic changes within periarticular tissues.[18]

The pathophysiological basis for these findings may be explained by persistent hyperglycaemia, which induces excessive collagen cross-linking, reduced tissue elasticity, and chronic low-grade inflammation within the glenohumeral capsule. Advanced glycation end products stimulate fibroblast proliferation and increase collagen deposition, leading to progressive capsular contracture and restriction of shoulder movements. Hsu et al. highlighted that these pathological changes contribute to prolonged disease duration and delayed recovery among diabetic patients with frozen shoulder.[19] Furthermore, Ramchurn et al. demonstrated that poor metabolic control is significantly associated with upper limb musculoskeletal abnormalities and greater functional disability in patients with diabetes mellitus.[20]

Overall, the findings of the present study demonstrate that poor glycaemic control is significantly associated with increased severity of frozen shoulder, greater pain and disability scores, and reduced shoulder mobility in patients with Type 2 Diabetes Mellitus. Early assessment of HbA1c levels may therefore facilitate identification of patients at increased risk of severe adhesive capsulitis and aid in planning timely multidisciplinary interventions. Optimizing glycaemic control may not only improve metabolic outcomes but may also reduce the severity and functional impact of frozen shoulder in diabetic individuals.

CONCLUSION

The present study demonstrated a significant association between poor glycaemic control and increased severity of frozen shoulder in patients with Type 2 Diabetes Mellitus. Patients with elevated HbA1c levels were more likely to present with severe pain, greater functional disability, and significant restriction of shoulder movements. Poor glycaemic control was significantly associated with higher SPADI scores and reduced shoulder abduction and external rotation. These findings emphasize the importance of routine assessment of glycaemic status in diabetic patients presenting with adhesive capsulitis. Early identification and optimal glycaemic control may contribute to improved clinical outcomes and reduced musculoskeletal morbidity. A multidisciplinary approach involving both orthopaedic and diabetic care is essential for the effective management of frozen shoulder in patients with Type 2 Diabetes Mellitus.

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