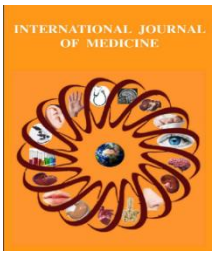

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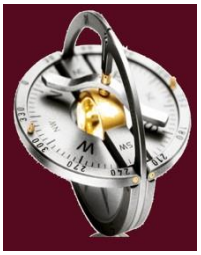

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Original Research

CORRELATION OF GLYCAEMIC CONTROL (HBA1C) WITH SEVERITY OF FROZEN SHOULDER IN PATIENTS WITH TYPE 2 DIABETES MELLITUS: A HOSPITAL-BASED OBSERVATIONAL STUDY.

Dr. ASHISH B C

Assistant Professor, Consultant Orthopaedic Surgeon (Joint Replacement, Arthroscopy and Trauma), Department of Orthopaedics, Basaveshwara Medical College and Hospital, Chitradurga, Karnataka, India.

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Abstract

Background: Frozen shoulder (adhesive capsulitis) is a common musculoskeletal complication in patients with Type 2 Diabetes Mellitus (T2DM). Chronic hyperglycaemia promotes collagen glycation, capsular fibrosis, and joint stiffness, potentially increasing the severity of frozen shoulder. Glycated haemoglobin (HbA1c) is a reliable indicator of long-term glycaemic control and may be associated with disease severity. However, evidence regarding this relationship remains limited, particularly in the Indian population. *Aim:* To evaluate the correlation between glycaemic control (HbA1c) and the severity of frozen shoulder in patients with Type 2 Diabetes Mellitus. *Objectives:* (1) To assess glycaemic control using HbA1c levels in patients with T2DM and frozen shoulder. (2) To determine the correlation between HbA1c levels and the severity of frozen shoulder using the Shoulder Pain and Disability Index (SPADI). *Materials and Methods:* A hospital-based cross-sectional observational study was conducted among **50** patients with Type 2 Diabetes Mellitus diagnosed with frozen shoulder. After obtaining informed consent, demographic details, duration of diabetes, clinical characteristics, and shoulder examination findings were recorded. HbA1c was estimated using High-Performance Liquid Chromatography (HPLC). Patients were categorized into good (<7%), moderate (7.0–8.9%), and poor (≥9%) glycaemic control groups. The severity of frozen shoulder was assessed using the SPADI score and shoulder range of motion. Data were analysed using IBM SPSS Statistics version 26.0. Chi-square test, One-way ANOVA, and Pearson's correlation coefficient were used for statistical analysis. A p-value <0.05 was considered statistically significant. *Results:* The mean age of the participants was 54.2 ± 7.8 years, and 56% were males. The mean duration of diabetes was 8.6 ± 4.3 years, while the mean HbA1c level was 8.4 ± 1.6%. Poor glycaemic control (HbA1c ≥9%) was observed in 40% of patients. Severe frozen shoulder was significantly more common among patients with poor glycaemic control ($p<0.001$). Mean total SPADI scores increased progressively from 29.6 ± 8.7 in patients with HbA1c <7% to 65.7 ± 11.4 in those with HbA1c ≥9% ($p<0.001$). HbA1c showed a strong positive correlation with total SPADI score ($r = 0.72$, $p<0.001$) and significant negative correlations with shoulder abduction ($r = −0.59$, $p<0.001$) and external rotation ($r = −0.63$, $p<0.001$). *Conclusion:* Poor glycaemic control is significantly associated with greater severity of frozen shoulder, increased pain, higher disability scores, and reduced shoulder mobility in patients with Type 2 Diabetes Mellitus. Regular monitoring of HbA1c and maintenance of optimal glycaemic control, combined with early physiotherapy and appropriate orthopaedic intervention, may reduce the severity of adhesive capsulitis and improve functional outcomes.

Keywords: *Type 2 Diabetes Mellitus; Frozen Shoulder; Adhesive Capsulitis; HbA1c; Glycaemic Control; SPADI.*

Introduction

Diabetes mellitus (DM) is one of the fastest-growing non-communicable diseases worldwide and represents a major public health challenge. Type 2 diabetes mellitus (T2DM) accounts for nearly 90-95% of all diabetes cases and is associated with both microvascular and macrovascular complications as well as several musculoskeletal disorders that adversely affect quality of life. According to the International Diabetes Federation (IDF) Diabetes Atlas 2025, more than 589 million adults are living with diabetes globally, and this number is projected to increase substantially over the coming decades.[1] India has one of the largest populations of individuals with diabetes and is often referred to as the "diabetes capital of the world." The increasing prevalence of obesity, sedentary lifestyle, urbanization, and ageing has contributed to a rapid rise in T2DM. Along with vascular complications, musculoskeletal manifestations such as adhesive capsulitis, trigger finger, Dupuytren's contracture, and limited joint mobility are increasingly recognized as important causes of disability among diabetic patients. [2]

Address for Correspondence Dr. ASHISH B C, Assistant Professor, Consultant Orthopaedic Surgeon (Joint Replacement, Arthroscopy and Trauma), Department of Orthopaedics, Basaveshwara Medical College and Hospital, Chitradurga, Karnataka, India.

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Frozen shoulder, also known as adhesive capsulitis, is a chronic fibro-proliferative disorder characterized by progressive shoulder pain and marked restriction of both active and passive range of motion. The condition usually progresses through painful, frozen, and thawing phases and significantly interferes with activities of daily living including dressing, grooming, overhead activities and sleep. The global prevalence in the general population is estimated to be 2-5%, whereas diabetic patients have a substantially higher prevalence. [3]

Several epidemiological studies have demonstrated a strong association between diabetes mellitus and frozen shoulder. A meta-analysis by Zreik et al. reported that patients with diabetes were nearly five times more likely to develop adhesive capsulitis than non-diabetic individuals, with an overall prevalence of 13.4% among diabetic patients, while approximately 30% of patients presenting with frozen shoulder were found to have diabetes.[4] The exact pathogenesis of adhesive capsulitis in diabetes remains incompletely understood. Chronic hyperglycaemia promotes the formation of advanced glycation end-products (AGEs), which accumulate within collagen fibres of the glenohumeral capsule. These AGEs increase collagen cross-linking, stimulate inflammatory cytokines, fibroblast proliferation and capsular fibrosis, ultimately resulting in pain, stiffness and progressive restriction of shoulder movements. Persistent hyperglycaemia may therefore accelerate both the onset and severity of frozen shoulder. [5]

Glycaemic control is routinely assessed using glycated haemoglobin (HbA1c), which reflects the average blood glucose concentration over the preceding two to three months. HbA1c is considered the gold standard marker for long-term glycaemic control and is closely associated with the development of diabetic complications. Several studies suggest that patients with poor glycaemic control have an increased risk of developing adhesive capsulitis and may experience more severe pain, greater restriction of movement and prolonged recovery.[6] In India, the burden of adhesive capsulitis among diabetic patients is particularly important because of the large diabetic population and delayed presentation to healthcare facilities. Indian studies have reported a high prevalence of frozen shoulder among individuals with T2DM and have emphasized the adverse impact of prolonged hyperglycaemia on shoulder function and quality of life. Poor glycaemic control has been identified as a potentially modifiable risk factor that may influence disease severity and treatment outcomes.

Although numerous studies have established an association between diabetes and frozen shoulder, evidence correlating HbA1c levels with the clinical severity of adhesive capsulitis remains limited and inconsistent. Some investigators have demonstrated a significant positive correlation between HbA1c and shoulder disability, whereas others have reported only modest associations after adjustment for disease duration and other confounding factors. Therefore, further hospital-based observational studies are required to clarify this relationship, particularly in the Indian population. Understanding the relationship between glycaemic control and frozen shoulder severity has important clinical implications. If poor glycaemic control is associated with more severe disease, early identification of elevated HbA1c and optimization of diabetes management may reduce disability, improve functional outcomes and enhance the effectiveness of physiotherapy and other therapeutic interventions.

Hence, the present study was undertaken to evaluate the correlation between glycaemic control (HbA1c) and the severity of frozen shoulder in patients with Type 2 Diabetes Mellitus attending a tertiary care hospital. The findings of this study may contribute to early risk stratification, comprehensive diabetic care and improved musculoskeletal health among individuals with T2DM.

Aim
To evaluate the correlation between glycaemic control (HbA1c) and the severity of frozen shoulder in patients with Type 2 Diabetes Mellitus attending a tertiary care hospital.

Objectives
1. To assess the glycaemic control of patients with Type 2 Diabetes Mellitus using glycated haemoglobin (HbA1c) levels.
2. To determine the correlation between HbA1c levels and the severity of frozen shoulder using clinical assessment and the Shoulder Pain and Disability Index (SPADI) score.

Materials and Methods
Study Design
A Hospital-based cross-sectional observational study.

Study Population
Patients with Type 2 Diabetes Mellitus diagnosed with frozen shoulder attending the Orthopaedics outpatient department.

Sample Size
A total of **50 patients** fulfilling the eligibility criteria will be included in the study.

Sampling Technique
Consecutive sampling.

Inclusion Criteria
- Patients aged **40-70 years**.
- Diagnosed cases of **Type 2 Diabetes Mellitus**.
- Clinical diagnosis of **primary frozen shoulder (adhesive capsulitis)** with pain and restriction of both active and passive shoulder movements for more than one month.
- Patients willing to provide written informed consent.

Exclusion Criteria
- History of shoulder trauma, fracture or dislocation.
- Previous shoulder surgery.
- Rotator cuff tear, shoulder osteoarthritis or inflammatory arthritis.
- Cervical radiculopathy or neurological disorders affecting shoulder function.
- Secondary adhesive capsulitis due to stroke, thyroid disorders or malignancy.
- Patients with Type 1 Diabetes Mellitus.
- Patients unwilling to participate.

Study Procedure
After obtaining approval from the Institutional Ethics Committee and written informed consent, eligible patients will be recruited consecutively. A detailed history including age, sex, duration of diabetes, duration of shoulder symptoms, occupation, body mass index (BMI), comorbidities and treatment history will be recorded using a predesigned case record form. A complete clinical examination of the affected shoulder will be performed. Active and passive range of motion, including forward flexion, abduction, external rotation and internal rotation, will be measured using a universal goniometer. Frozen shoulder will be diagnosed based on characteristic clinical findings of pain and restriction of shoulder

movements.
The severity of frozen shoulder will be assessed using the Shoulder Pain and Disability Index (SPADI) questionnaire. The SPADI consists of pain and disability subscales with scores ranging from 0 to 100, where higher scores indicate greater severity and functional impairment.

Venous blood samples (3-5 mL) will be collected under aseptic precautions for estimation of HbA1c, which will be measured using High-Performance Liquid Chromatography (HPLC) in the institutional central laboratory.
Patients will be categorized according to glycaemic control as follows:

- Good glycaemic control: **HbA1c <7.0%**
- Moderate glycaemic control: **HbA1c 7.0-8.9%**
- Poor glycaemic control: **HbA1c ≥9.0%**

The relationship between HbA1c levels and frozen shoulder severity will be evaluated using SPADI scores and shoulder range of motion measurements.

Statistical Analysis
Data will be entered into Microsoft Excel and analysed using IBM SPSS Statistics version 26.0. Continuous variables will be expressed as Mean ± Standard Deviation (SD). Categorical variables will be expressed as Frequency and Percentage. Comparison of mean SPADI scores among HbA1c categories will be performed using One-way Analysis of Variance (ANOVA). Association between categorical variables will be analysed using the Chi-square test or Fisher's Exact test, wherever appropriate. Correlation between HbA1c levels and SPADI score, as well as shoulder range of motion, will be assessed using Pearson's correlation coefficient (or Spearman's rank correlation if the data are not normally distributed). A p-value <0.05 will be considered statistically significant.

Results
A total of 50 patients with Type 2 Diabetes Mellitus diagnosed with frozen shoulder were included in the study. The mean age of the study participants was 54.2 ± 7.8 years, and the mean HbA1c level was 8.4 ± 1.6%. Poor glycaemic control was associated with significantly greater pain, disability and restriction of shoulder movements.

Table 1. Distribution of patients according to demographic characteristics

Variable	Category	Frequency (n)	Percentage (%)
Age (years)	40-49	12	24.0
	50-59	22	44.0
	60-70	16	32.0
Gender	Male	28	56.0
	Female	22	44.0
Duration of Diabetes	<5 years	14	28.0
	5-10 years	21	42.0
	>10 years	15	30.0

Descriptive statistics: Mean age = **54.2 ± 7.8 years**; Mean duration of diabetes = **8.6 ± 4.3 years**.
Interpretation
Most patients belonged to the **50-59 years** age group (44%), and males constituted **56%** of the study population. Nearly three-fourths of the patients had diabetes for more than five years, indicating that frozen shoulder was more common among patients with long-standing diabetes.

Table 2. Distribution according to HbA1c level and severity of frozen shoulder

HbA1c Category	HbA1c (%)	Frequency (n)	Percentage (%)
Good control	<7.0	12	24.0
Moderate control	7.0-8.9	18	36.0
Poor control	≥9.0	20	40.0
Total		**50**	**100**

Mean HbA1c = **8.4 ± 1.6%**

Interpretation
Forty percent of patients had poor glycaemic control (HbA1c ≥9%), whereas only 24% achieved good glycaemic control. This indicates that inadequate glycaemic control was common among diabetic patients presenting with frozen shoulder.

Table 3. Association between HbA1c category and severity of frozen shoulder (SPADI)

HbA1c Category	Mild n (%)	Moderate n (%)	Severe n (%)	Total	p-value
Good (<7%)	8	4	0	12	
Moderate (7-8.9%)	4	11	3	18	**<0.001**
Poor (≥9%)	1	5	14	20	
Total	**13**	**20**	**17**	**50**	

Interpretation
Patients with poor glycaemic control had significantly more severe frozen shoulder than those with good glycaemic control (χ^2 test, $p<0.001$). Seventy percent of patients with HbA1c ≥9% had severe SPADI scores.

Table 4. Comparison of SPADI scores according to HbA1c categories

Variable	HbA1c <7% (n=12) Mean ± SD	HbA1c 7-8.9% (n=18) Mean ± SD	HbA1c ≥9% (n=20) Mean ± SD	F-value	p-value
Pain Score	28.4 ± 8.2	43.6 ± 9.4	61.8 ± 10.5	36.74	<0.001
Disability Score	30.5 ± 9.8	48.9 ± 11.2	69.6 ± 12.1	42.18	<0.001
Total SPADI Score	29.6 ± 8.7	46.2 ± 10.3	65.7 ± 11.4	40.56	<0.001

Interpretation
Mean SPADI pain, disability and total scores increased significantly with increasing HbA1c levels. Patients with HbA1c ≥9% had the highest disability scores, demonstrating that poor glycaemic control was associated with more severe frozen shoulder.

Table 5. Correlation of HbA1c with clinical parameters

Parameter	Correlation coefficient (r)	p-value
Total SPADI score	0.72	<0.001
Pain score	0.68	<0.001
Disability score	0.70	<0.001
Duration of diabetes	0.49	<0.001
Shoulder abduction ROM	-0.59	<0.001
External rotation ROM	-0.63	<0.001

Interpretation
HbA1c showed a strong positive correlation with SPADI pain, disability and total scores, indicating that higher HbA1c levels were associated with greater severity of frozen shoulder. A significant negative correlation was observed between HbA1c and shoulder range of motion, suggesting that worsening glycaemic control was associated with increased restriction of shoulder movements.

Overall Results
Among 50 patients with Type 2 Diabetes Mellitus and frozen shoulder, poor glycaemic control was common, with 40% of patients having HbA1c ≥9%. Patients with higher HbA1c levels demonstrated significantly greater pain, disability, higher SPADI scores and reduced shoulder mobility. Statistical analysis showed a significant association between HbA1c category and frozen shoulder severity (Chi-square test, **p<0.001**) and a strong positive correlation between HbA1c and total SPADI score (**r = 0.72, p<0.001**), indicating that poor glycaemic control is associated with increased severity of frozen shoulder.

Discussion

The present hospital-based study evaluated the correlation between glycaemic control and frozen shoulder severity among 50 patients with Type 2 Diabetes Mellitus. The mean age was 54.2 ± 7.8 years, and the largest proportion of patients belonged to the 50-59-year age group, indicating that diabetic frozen shoulder commonly affects middle-aged and older adults. This age distribution is comparable to Yian et al., who reported a greater occurrence of frozen shoulder among older patients with long-standing diabetes.[8]

Males constituted 56% of the present study, although previous studies have reported variable gender distributions, suggesting that glycaemic exposure and diabetes duration may be more important than sex alone. The mean duration of diabetes was 8.6 ± 4.3 years, and 72% of patients had diabetes for more than five years. Yian et al. found that diabetes lasting more than 10 years was associated with higher odds of frozen shoulder than diabetes of less than five years' duration (OR 1.85).[8] In the present study, mean HbA1c was 8.4 ± 1.6%, while 40% had poor glycaemic control with HbA1c ≥9%, 36% had moderate control and only 24% had good control. Chan et al. reported that cumulative HbA1c was significantly associated with adhesive capsulitis and that each unit increase in cumulative HbA1c exposure increased the risk by approximately 2.77%.[9] These findings support the concept that prolonged hyperglycaemia produces cumulative structural changes in the shoulder capsule rather than acting only as a short-term precipitating factor.

However, Yian et al. did not identify a significant relationship between a single HbA1c measurement and frozen shoulder prevalence, demonstrating that cumulative glycaemic exposure and duration of diabetes may be more informative.[8] In the present study, severe frozen shoulder was found in 70% of patients with HbA1c ≥9%, whereas none of the patients with HbA1c <7% had severe disease. The association between HbA1c category and frozen shoulder severity was statistically significant (p<0.001), indicating that inadequate glycaemic control was associated with more severe symptoms and disability. Shah et al. similarly demonstrated greater limitation of shoulder mobility, particularly external rotation, among patients with diabetes than among non-diabetic controls.[10] Chronic hyperglycaemia promotes advanced glycation end-product formation, collagen cross-linking, capsular thickening and fibroblast proliferation, which may explain the increased stiffness observed with higher HbA1c levels.[11] Mean total SPADI scores increased from 29.6 ± 8.7 among patients with HbA1c <7% to 46.2 ± 10.3 among those with HbA1c 7-8.9% and 65.7 ± 11.4 among those with HbA1c ≥9%. Pain and disability scores also increased significantly across the three glycaemic-control groups (p<0.001), confirming poorer shoulder function among patients with uncontrolled diabetes. Dyer et al., in a systematic review, found that diabetes was associated with worse clinical scores, greater persistent pain and poorer range of movement among patients with frozen shoulder.[12] Their findings are consistent with the higher SPADI pain and disability scores recorded among poorly controlled diabetic patients in the present study. HbA1c showed a strong positive correlation with total SPADI score (r=0.72, p<0.001), pain score (r=0.68) and disability score (r=0.70). The observed dose-response relationship agrees with systematic evidence that diabetes increases both the risk and adverse prognosis of frozen shoulder.[13,14]

HbA1c also showed significant negative correlations with shoulder abduction (r=−0.59) and external rotation (r=−0.63), indicating progressively restricted movement with worsening glycaemic control. Studies of ultrasound-guided hydrodistension have similarly reported that diabetic patients present with more severe adhesive capsulitis, experience more frequent recurrence and obtain poorer functional outcomes than non-diabetic patients.[15,16] Reviews of diabetic shoulder dysfunction further support a multifactorial mechanism involving capsular fibrosis, altered collagen metabolism, microvascular disease, inflammation and reduced tendon quality.[17,18] Although the cross-sectional design cannot establish causality and HbA1c represented glycaemic control over only the preceding two to three months, the strong correlations observed across SPADI and range-of-motion measures indicate a clinically relevant association. Overall, the findings suggest that strict and sustained glycaemic control, combined with early physiotherapy and appropriate orthopaedic management, may help reduce pain, disability and movement restriction in patients with diabetic frozen shoulder.

Conclusion
The present study demonstrated a significant positive correlation between poor glycaemic control, as assessed by HbA1c levels, and the severity of frozen shoulder in patients with Type 2 Diabetes Mellitus. Patients with higher HbA1c levels had significantly greater pain, disability, higher SPADI scores, and reduced shoulder range of motion compared to those with better glycaemic control. Poor glycaemic control was also associated with more severe grades of adhesive capsulitis, indicating that persistent hyperglycaemia may contribute to the progression of capsular fibrosis and functional impairment. These findings emphasize the importance of routine HbA1c assessment in diabetic patients presenting with shoulder pain and stiffness. Early optimization of glycaemic control, along with timely physiotherapy and appropriate orthopaedic management, may help reduce disease severity, improve shoulder function, and enhance quality of life. Further prospective multicentric studies with larger sample sizes are recommended to establish the causal relationship between long-term glycaemic control and frozen shoulder severity.

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