Original Research

INSULIN INJECTION TECHNIQUE: EVALUATING THE GAP BETWEEN GUIDELINE RECOMMENDATIONS AND CLINICAL PRACTICE

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ABSTRACT

Background: Diabetes mellitus (DM) is a major chronic metabolic disorder with rapidly increasing global prevalence. In India, approximately 69.9 million individuals are living with diabetes, and nearly 3.2 million depend on insulin therapy. Improper insulin injection technique is a significant and modifiable contributor to poor glycemic control. Aim: To evaluate insulin injection practices among long-term insulin users and identify gaps between recommended guidelines and real-world clinical practices. Materials and Methods: This cross-sectional observational study was conducted in the Department of Endocrinology at a tertiary care center from January 2020 to December 2024. A total of 500 patients diagnosed with diabetes mellitus and receiving insulin therapy for a minimum duration of five years were enrolled during their first visit to our center. A FITTER-based structured questionnaire was used to assess knowledge and practices related to injection technique. Demographic data and HbA1c values were recorded. Multivariate logistic regression analysis was performed to identify predictors of poor glycemic control (HbA1c > 8%). Results: The mean age of participants was 58.4 years, and the mean HbA1c was 9.11%. Most participants had type 2 diabetes (81%). Nearly 47% were unaware of correct injection sites, and the thigh was the most commonly used site (61%), while only 17% used the abdomen. A majority were unaware of the correct injection angle (78%), needle length (71.6%), and insulin concentration differences (90.2%). Needle reuse was common, with an average reuse of three times. Only 18% waited 5–10 seconds before withdrawing the needle. Lipohypertrophy was observed in 12.6% of participants. Lack of structured training, needle reuse, improper site rotation, and lipohypertrophy were independently associated with poor glycemic control. Conclusion: There is a substantial gap between guideline-recommended insulin injection practices and actual patient behavior. Structured and repeated diabetes education programs are essential to improve glycemic outcomes and reduce injection-related complications.

Keywords: Diabetes Mellitus, Insulin Therapy, Injection Technique, Lipohypertrophy, Glycemic Control, Patient Education.

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INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by persistent hyperglycaemia resulting from defects in insulin secretion, insulin action, or both [1]. It has emerged as one of the most significant global public health challenges of the 21st century. Rapid urbanization, sedentary lifestyle, unhealthy dietary habits, obesity, and population aging have contributed substantially to the rising prevalence of diabetes worldwide [2]. India, often referred to as the "Diabetes Capital of the World," currently has approximately 69.9 million individuals living with diabetes, and this number is projected to increase considerably in the coming decades [3]. The growing burden of diabetes poses major challenges to healthcare systems due to its long-term complications and economic impact. Optimal glycemic control is essential to prevent both microvascular and macrovascular complications of diabetes, including retinopathy, nephropathy, neuropathy, coronary artery disease, and stroke [4].

Insulin therapy remains the cornerstone of treatment for individuals with Type 1 Diabetes Mellitus (T1DM) and for many patients with advanced Type 2 Diabetes Mellitus (T2DM). Although oral hypoglycemic agents are effective in early disease stages, a significant proportion of patients eventually require insulin to achieve adequate metabolic control [5]. Over the past few decades, substantial advancements have been made in insulin formulations, including rapid-acting analogues, long-acting basal analogues, and premixed preparations [6]. Improvements in delivery systems such as insulin pens and shorter, finer needles have enhanced patient convenience and reduced discomfort [7]. However, the effectiveness of insulin therapy depends not only on the type and dose of insulin prescribed but also on proper injection technique [8].

Correct insulin injection technique ensures consistent subcutaneous delivery, predictable absorption, and stable glycemic control [8]. International organizations such as the American Diabetes Association (ADA) and the Forum for Injection Technique & Therapy Expert Recommendations (FITTER) have issued comprehensive guidelines outlining best practices. These include appropriate site selection, systematic rotation of injection sites, correct needle length and insertion angle, avoidance of needle reuse, adequate dwell time before needle withdrawal, proper skin-fold technique, and awareness of insulin concentration compatibility [9].

Failure to adhere to recommended injection practices may result in lipohypertrophy, erratic insulin absorption, glycemic variability, hypoglycemia, dosing errors, and increased risk of infection [10]. Repeated injections at the same site can lead to lipohypertrophy, which further impairs insulin absorption and contributes to poor glycemic control. Needle reuse may increase tissue trauma and discomfort, while incorrect injection depth may lead to inadvertent intramuscular administration [11]. Despite the availability of clear guidelines, real-world adherence to recommended injection techniques remains suboptimal. In many settings, education regarding insulin administration is limited to initial counseling at the time of therapy initiation, with minimal reinforcement during follow-up visits [12]. Additional barriers such as low literacy levels, socioeconomic constraints, limited access to diabetes educators, fear of injections, and cultural beliefs may further compromise proper technique [13].

There is limited real-world data assessing adherence to insulin injection guidelines in tertiary care settings, particularly in developing countries [14]. Understanding the gap between recommended practices and actual patient behavior is essential for designing targeted educational interventions and improving glycemic outcomes [15]. Therefore, the present study was undertaken to comprehensively evaluate insulin injection techniques among long-term insulin users attending a tertiary care center and to identify areas where current practices deviate from established guidelines [16, 17, 18].

MATERIALS AND METHODS

2.1 Study Design and Setting

This cross-sectional observational study was conducted in the Department of Endocrinology at a tertiary care center between January 2020 and December 2024.

2.2 Study Population

A total of 500 patients diagnosed with diabetes mellitus and receiving insulin therapy for a minimum duration of five years were enrolled during their first visit to our center. The participants were determined based on feasibility and availability of eligible patients during the study period. A consecutive sampling method was adopted to minimize selection bias.

2.2.1. Inclusion Criteria

i. Age ≥ 18 years.
ii. Diagnosed with Type 1 Diabetes Mellitus (T1DM) or Type 2 Diabetes Mellitus (T2DM).
iii. Receiving insulin therapy for at least five years.
iv. Using insulin administered via syringe or insulin pen device.
v. Attending regular follow-up visits at the endocrinology outpatient department.
vi. Provided written informed consent to participate in the study.

2.2.2. Exclusion Criteria

i. Receiving insulin therapy for less than five years.
ii. Using continuous subcutaneous insulin infusion (insulin pump therapy).
iii. Diagnosed with gestational diabetes mellitus.
iv. Critically ill at the time of recruitment.

v. Unable to comprehend or respond to the questionnaire.
vi. Declined to provide written informed consent.

2.3. Data Collection

Data were collected using a structured, FITTER-based Insulin Injection Technique Questionnaire administered during routine outpatient visits. The questionnaire was designed to assess both knowledge and actual practices related to insulin administration. The following domains were evaluated:

- Knowledge of appropriate injection sites
- Site rotation practices
- Awareness of needle length
- Knowledge of correct injection angle
- Awareness of insulin concentration (40 IU vs 100 IU compatibility)
- Needle reuse practices
- Skin-fold (pinch-up) technique
- Needle dwell time after insulin injection
- Injection-related complications (pain, bleeding, lipohypertrophy)
- History of formal training in insulin injection technique
- Confidence level in administering insulin

Demographic details, including age, gender, educational status, socioeconomic status, type of diabetes, duration of diabetes, and duration of insulin therapy, were recorded. The most recent HbA1c value available in the medical records was documented for assessment of glycemic control. All questionnaires were administered by trained healthcare personnel to ensure clarity and completeness of responses.

2.4. Operational Definitions

For the purpose of this study, the following operational definitions were applied:

i) Proper insulin injection technique was defined according to the Forum for Injection Technique & Therapy Expert Recommendations (FITTER) guidelines and included:

- Selection of appropriate subcutaneous injection sites (abdomen, thigh, upper arm, or buttocks)
- Systematic rotation of injection sites to avoid repeated injections at the same location
- Use of the correct needle insertion angle (90° or 45°, as appropriate)
- Awareness and use of appropriate needle length
- Adequate needle dwell time (maintaining the needle under the skin for 5–10 seconds before withdrawal)
- Avoidance of needle reuse
- Use of correct insulin concentration with compatible syringe (40 IU or 100 IU)

ii) Needle reuse was defined as using the same needle more than once for insulin administration.

iii) Lipohypertrophy was defined as the presence of localized swelling or thickened fatty tissue at injection sites, identified either by patient report or clinical examination.

iv) Poor glycemic control was defined as glycated hemoglobin (HbA1c) level greater than 8%.

2.5 Clinical Parameters

Baseline demographic and clinical characteristics were recorded for all study participants. The variables such as age (years), gender, educational status, socioeconomic status, Place of residence (urban/rural), Type of diabetes mellitus (Type 1 or Type 2), Duration of diabetes, Type of insulin delivery device (syringe or insulin pen) and recent glycated hemoglobin (HbA1c) level were documented. HbA1c values were retrieved from medical records at the time of enrolment and were used to assess glycemic control. Poor glycemic control was defined as HbA1c > 8%, as per the predefined study criteria. All clinical parameters were recorded using a standardized data collection proforma to ensure uniformity and accuracy.

2.6 Data Confidentiality

All data collected during the study were treated with strict confidentiality. Participants were assigned unique identification codes, and no personal identifiers were used during data entry or analysis. Completed questionnaires and clinical data were stored securely with restricted access limited to the principal investigators. Electronic data were password-protected and maintained on secure institutional systems. The study complied with institutional ethical standards for data protection and confidentiality. No individual participant information was disclosed at any stage of the study.

2.7 Ethical Considerations

The study protocol was approved by the Institutional Ethics Committee prior to initiation. Written informed consent was obtained from all participants. Participation was voluntary, and patients were informed of their right to withdraw at any time without affecting their treatment. The study was conducted in accordance with the principles of the Declaration of Helsinki, and confidentiality of participant information was strictly maintained.

2.9 Statistical Analysis

Data were entered into Microsoft Excel and analyzed using the Statistical Package for the Social Sciences (SPSS) software, version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables, such as age and HbA1c, were expressed as mean ± standard deviation (SD). Categorical variables were presented as frequencies and percentages. Inferential statistical analysis was performed to assess associations between injection technique practices and glycemic control. Multivariate logistic regression analysis was conducted to identify independent predictors of

poor glycemic control, defined as HbA1c > 8%. A p-value of < 0.05 was considered statistically significant.

RESULTS

3.1 Demographic Characteristics of Study Participants

A total of 500 patients with diabetes mellitus on insulin therapy were included in the study. The mean age was 58.4 years, and the mean HbA1c was 9.11%, indicating overall poor glycemic control among the cohort. Females constituted a substantial majority (72%), while males accounted for 28%. Most participants had T2DM (81%), with only 19% having T1DM. A larger proportion of the study population resided in urban areas (67%) compared to rural areas (33%). Regarding socioeconomic status, the majority (79%) reported a monthly income between 10,000–20,000 INR, while 12% earned less than 10,000 INR and 9% earned between 20,000–30,000 INR. Educational attainment varied, with 38% having completed schooling, 34% being illiterate, and 28% holding a graduate degree (Table 1). These findings indicate that the study population predominantly comprised urban, middle-income individuals with varying educational backgrounds and a high burden of uncontrolled diabetes.

Table 1: Demographic Characteristics of Study Participants (N = 500)

Variable	Frequency (n)	Percentage (%)
Gender		
Male	140	28
Female	360	72
Type of Diabetes		
Type 1 DM	95	19
Type 2 DM	405	81
Place of Residence		
Urban	335	67
Rural	165	33
Socioeconomic Status (Monthly Income)		
<10,000 INR	60	12
10,000–20,000 INR	395	79
20,000–30,000 INR	45	9
Education		
Illiterate	170	34
Completed Schooling	190	38
Graduate	140	28

Data are presented as frequency (n) and percentage (%). Socioeconomic status was categorized based on self-reported monthly household income in Indian Rupees (INR).

3.2 Knowledge Regarding Insulin Injection Technique

Table 2 outlines participants' knowledge of appropriate insulin injection techniques. Slightly more than half (53%) were aware of the correct injection site, while 47% lacked this knowledge. The thigh was the most commonly identified injection site (61%), followed by the upper arm (22%) and abdomen (17%). Awareness of site rotation was limited, with only 49% reporting knowledge of this important practice. Knowledge gaps were more pronounced regarding technical aspects: only 22% were aware of the correct injection angle, 28.4% knew the appropriate needle length, and a mere 9.8% were aware of the correct insulin concentration (40 IU vs. 100 IU). Overall, the table highlights significant deficiencies in patient knowledge, particularly concerning technical details critical for effective insulin administration.

Table 2: Knowledge Regarding Insulin Injection Technique

Variable	Frequency (n)	Percentage (%)
Correct Injection Site Known		

Yes	265	53
No	235	47
Common Injection Site Used		
Thigh	305	61
Abdomen	85	17
Upper Arm	110	22
Aware of Site Rotation		
Yes	245	49
No	255	51
Aware of Correct Injection Angle		
Yes	110	22
No	390	78
Aware of Needle Length		
Yes	142	28.4
No	358	71.6
Aware of Insulin Concentration (40 IU/100 IU)		
Yes	49	9.8
No	451	90.2

Data are presented as frequency (n) and percentage (%) of the total study population (N = 500). Knowledge variables were assessed using a structured FITTER-based questionnaire. "Aware" indicates correct response to guideline-recommended insulin injection practices. Percentages were calculated using the total number of participants as the denominator.

3.3. Current Injection Practices

The majority (63.8%) used syringes, while 36.2% used pen devices. About 59.4% practiced the skin fold technique, whereas 40.6% either did not practice it or were unaware of it. Needle dwell time varied considerably: 51.4% kept the needle in place for 1–3 seconds, 18% for 5–10 seconds, 8.6% for more than 10 seconds, and 22% were unaware of the appropriate duration. Needle reuse was common, with 48.2% reusing needles for 2–3 times and 51.8% continuing reuse until the needle felt dull. Injection-related complications were frequently reported, with pain being the most common (72.4%), followed by bleeding (15%) and lipohypertrophy (12.6%). These findings suggest suboptimal injection practices and a high prevalence of preventable complications (Table 3).

Table 3: Current Injection Practices

Variable	Frequency (n)	Percentage (%)
Device Used		
Syringe	319	63.8
Pen Device	181	36.2
Skin Fold Technique Practiced		
Yes	297	59.4
No / Not Aware	203	40.6
Needle Dwell Time		
1–3 seconds	257	51.4
5–10 seconds	90	18
>10 seconds	43	8.6
Not Aware	110	22
Needle Reuse		
After 2–3 Uses	241	48.2

When Feels Dull	259	51.8
Injection Complications		
Pain	362	72.4
Bleeding	75	15
Lipohypertrophy	63	12.6

Data are presented as frequency (n) and percentage (%) of the total study population (N = 500). Needle dwell time refers to the duration the needle was kept under the skin before withdrawal. Injection-related complications include pain, bleeding, and clinically identified lipohypertrophy.

3.4. Training and Confidence

In terms of structured training, 186 participants had received formal training in insulin injection technique, whereas 314 had not received any structured instruction. Confidence levels were generally low: 198 participants (39.6%) reported being not confident, 185 (37%) were somewhat confident and only 67 (13.4%) considered themselves confident in their technique; 10% did not respond (Figure 1). A significant majority (72%) expressed the need for additional guidance, indicating dissatisfaction or uncertainty regarding their current knowledge and skills (Table 4). These findings emphasize the lack of adequate patient education and the need for improved training interventions.

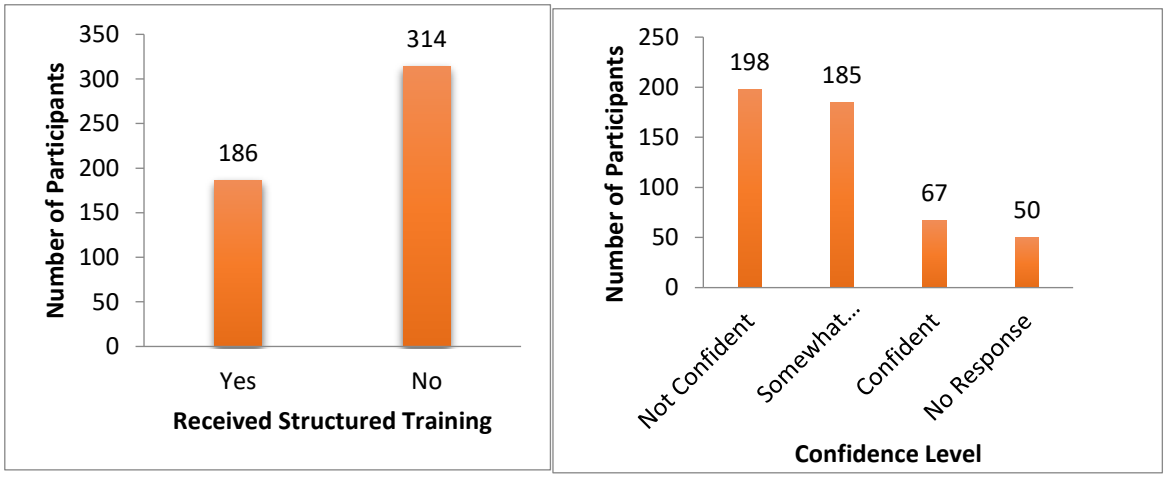

Figure 1: Level of Training and Confidence in Insulin Injection Technique

Table 4: Training and Confidence

Variable	Frequency (n)	Percentage (%)
Received Structured Training		
Yes	186	37.2
No	314	62.8
Confidence in Injection Technique		
Not Confident	198	39.6
Somewhat Confident	185	37
Confident	67	13.4
No Response	50	10
Need Additional Guidance		
Yes	360	72
No	140	28

Data are presented as frequency (n) and percentage (%). Structured training refers to formal instruction on insulin injection technique provided by healthcare professionals. Confidence levels were self-reported by participants.

3.3. Predictors of Poor Glycemic Control (HbA1c > 8%)

Table 5 represents the factors significantly associated with poor glycemic control (HbA1c > 8%). Patients who had not received structured training were 2.4 times more likely to have poor glycemic control (OR 2.4; 95% CI: 1.5–3.8; p=0.001). Needle reuse was associated with a 1.9-fold increased risk (OR 1.9; 95% CI: 1.2–3.0; p=0.004). Failure to rotate injection sites increased the odds by 2.1 times (OR 2.1; 95% CI: 1.3–3.4; p=0.002). The strongest association was observed with lipohypertrophy, which increased the likelihood of poor glycemic control by 2.7 times (OR 2.7; 95% CI: 1.6–4.2; p<0.001). These statistically significant findings demonstrate that improper injection practices and lack of training are key determinants of inadequate glycemic control among insulin-treated patient

Table 5: Predictors of Poor Glycemic Control (HbA1c > 8%)

Variable	Odds Ratio (OR)	95% CI	p-value
No Structured Training	2.4	1.5–3.8	0.001
Needle Reuse	1.9	1.2–3.0	0.004
No Site Rotation	2.1	1.3–3.4	0.002
Lip hypertrophy	2.7	1.6–4.2	<0.001

Odds ratios (OR) were calculated using multivariate logistic regression analysis. Poor glycemic control was defined as HbA1c > 8%. A p-value $\leq$ 0.05 was considered statistically significant.

DISCUSSION

The present study highlights a substantial gap between guideline-recommended insulin injection practices and actual patient behavior in a tertiary care setting. Despite long-term insulin use (≥5 years), a significant proportion of participants demonstrated inadequate knowledge and improper injection practices, which were associated with poor glycemic control. Similar discrepancies between recommendations and real-world practice have been reported in previous studies [13].

Nearly half of the participants (47%) were unaware of the correct anatomical sites for insulin injection. The thigh was the most commonly used site (61%), whereas the abdomen—recommended for more consistent insulin absorption was used by only 17% of participants. Inadequate site selection and improper rotation can contribute to erratic insulin absorption and glycemic variability [10, 11]. Although 49% of participants were aware of the importance of site rotation, consistent and systematic rotation was not widely practiced. Repeated injections at the same site increase the risk of lipohypertrophy, which was observed in 12.6% of participants in this study. Lipohypertrophy was independently associated with poor glycemic control, consistent with previous literature demonstrating its negative impact on insulin absorption and glucose variability [12].

Knowledge gaps were also evident regarding injection angle (78% unaware), needle length (71.6% unaware), and insulin concentration compatibility (90.2% unaware). Lack of awareness regarding 40 IU and 100 IU insulin compatibility may result in dosing errors with significant clinical consequences [11, 13]. These findings suggest that essential aspects of insulin administration are not adequately reinforced during follow-up visits [14]. Needle reuse was common, with most participants reusing needles multiple times. This practice is known to increase tissue trauma, injection pain, risk of infection, and lipohypertrophy [11, 13]. The high prevalence of painful injections (72.4%) reported in this study may be partly attributable to repeated needle usage and improper technique.

A major concern identified in this study was the lack of structured training. Nearly two-thirds of participants (62.8%) had never received formal education regarding proper insulin injection techniques, despite long-term therapy. Structured education and retraining have been shown to significantly improve glycemic control and injection practices [14]. Furthermore, 39.6% lacked confidence in their injection technique, and 40% reported fear of injections leading to missed doses. Psychological and behavioural factors may further compromise adherence to insulin therapy [15]. The mean HbA1c of 9.11% reflects suboptimal glycemic control among participants. Multivariate analysis revealed that lack of structured training, needle reuse, absence of systematic site rotation, and presence of lipohypertrophy were independently associated with poor glycemic control. These findings underscore the clinical importance of proper injection technique as a modifiable factor influencing metabolic outcomes [10, 12, 14].

Overall, the results emphasize the urgent need for structured, repeated, and patient-centered diabetes education programs. Reinforcement of injection technique during routine outpatient visits, periodic inspection of injection sites, and addressing patient fears may significantly improve adherence and glycemic outcomes [14, 17].

LIMITATIONS

This study has certain limitations. First, it was conducted at a single tertiary care centre, where patients with diabetes who had been on insulin therapy for five years presented for the first time. The recruited subjects were prescribed insulin in primary and secondary care settings, where the details of the insulin education provided to the patients were not known. We did not include our own patients on insulin or under follow up to avoid bias. Second, injection practices were primarily self-reported and may be subject to recall or reporting bias. Finally, the cross-sectional design precludes establishing a causal relationship between injection practices and glycemic control.

CONCLUSION

The present study demonstrates a significant gap between guideline-recommended insulin injection practices and actual patient behaviour in the community. A large proportion of patients lacked adequate knowledge, had not received structured training, and practiced improper injection techniques, which were independently associated with poor glycemic control. These findings highlight the urgent need for structured, repeated, and patient-centered diabetes education programs. Regular reinforcement of proper injection technique and routine inspection of injection sites should be integrated into standard diabetes care to improve glycemic outcomes and reduce injection-related complications.

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