



# Insulin Injection Practices in a Population of Canadians with Diabetes: An Observational Study

Basel Bari · Marie-Andrée Corbeil · Hena Farooqui · Stuart Menzies ·  
Brian Pflug · Brennan K. Smith · Arthur Vasquez · Lori Berard

Received: July 23, 2020 / Published online: September 7, 2020  
© The Author(s) 2020

## ABSTRACT

**Introduction:** Proper insulin injection technique has demonstrated positive clinical outcomes in patients with diabetes. A Canadian-based practice reflective was undertaken to evaluate the current state of understanding of injection technique practices by patients administering insulin, and the importance physicians place on proper injection technique. **Methods:** Twenty-four sites across Canada completed a practice profile survey and enrolled adult non-pregnant patients with either type 1 or type 2 diabetes injecting insulin using an insulin pen. Seven areas of proper injection

technique to be evaluated were identified by the study steering committee: size of injection site, use of a skin lift, needle reuse, length of the needle, duration of the needle in the skin, injection into lipohypertrophic tissue, and applied injection force. During a scheduled visit, each patient filled out the Injection Technique Survey and the physician documented the answers via an electronic database. **Results:** Almost all physicians surveyed agreed (96%) that proper insulin injection technique is important or very important and 80% indicated they were either completely confident or fairly confident in discussing overall insulin injection technique. All patients surveyed were making at least one insulin injection technique error within the following categories: applied injection force (76%), area size of injection site (64%), duration of pen needle in skin (61%), pen needle reuse (39%), performs a skin lift with a 4 or 5 mm needle (38%), uses a longer pen needle than required (34%), and injection of insulin into lipohypertrophic tissue (37%).

**Digital Features** To view digital features for this article go to <https://doi.org/10.6084/m9.figshare.12808418>.

**Electronic Supplementary Material** The online version of this article (<https://doi.org/10.1007/s13300-020-00913-y>) contains supplementary material, which is available to authorized users.

B. Bari  
Markham HealthPlex Medical Centre, Markham,  
ON, Canada

M.-A. Corbeil  
Haut-Richelieu Medical Center, Saint-Jean-sur-  
Richelieu, QC, Canada

H. Farooqui · S. Menzies · B. K. Smith  
Medical Division, CTC Communications,  
Mississauga, ON, Canada

B. Pflug  
Becton, Dickinson and Company, Franklin Lakes,  
NJ, USA

A. Vasquez  
Marine Gateway Medical Clinic, Vancouver, BC,  
Canada

L. Berard (✉)  
Winnipeg, MB, Canada  
e-mail: ldberard@gmail.com

**Conclusion:** Patients commonly make insulin injection errors. Patient and physician education on optimal insulin injection technique continues to be an unmet medical need for the treatment of patients with diabetes. Prospective trials examining the impact of new technology, diabetes educational teams, and e-learning as educational interventions are potential avenues to explore in future studies to support improved insulin injection technique.

**Keywords:** Insulin injection technique; Patient education; Type 1 diabetes; Type 2 diabetes

### Key Summary Points

#### Why carry out this study?

Proper insulin injection technique has demonstrated positive clinical outcomes in patients with diabetes; however, the level of patient understanding of injection technique has not been recently examined.

To investigate patient injection technique, 24 sites across Canada enrolled adult non-pregnant patients with either type 1 or type 2 diabetes injecting insulin using an insulin pen to evaluate the current state of understanding of injection technique practices by patients administering insulin.

#### What was learned from the study?

All patients surveyed were making at least one insulin injection technique error. Of the patients surveyed, 5% were making one injection error, 22% were making two errors, 27% were making three errors, 22% were making four errors, 14% were making five errors, 6% were making six errors, and 2% were making seven errors.

To reduce insulin injection errors, additional patient and physician education is required.

## INTRODUCTION

Proper insulin injection technique may lead to more effective use of this therapy and, as such, holds the potential for improved clinical outcomes [1–3]. Avoiding insulin injection errors reduces the risk of glycemic excursions, intramuscular insulin injection, and lipohypertrophy in patients with type 1 and type 2 diabetes [4, 5]. Specifically, proper injection site area size, applied injection force, use of optimal needle length, duration of time needle is left in the skin, needle reuse, use of skin lifts, and injection into areas of lipohypertrophy have all been associated with a lack of clinical efficacy of insulin administration [1].

Despite the essential role of proper insulin injection technique in optimal diabetes management, previous patient surveys in many countries examining patient injection technique have consistently observed that a large number of injection errors are made [5–8]. To support a reduction in patient insulin injection errors, the updated 2017 Forum for Injection Technique (FIT) recommendations were developed to help educate and align the physician and patient regarding proper injection technique [9].

To investigate the alignment of patient insulin injection technique with recent guidelines, we aimed to evaluate the current state of understanding on proper insulin injection technique. We focused on size of area of injection site, needle length, needle reuse, skin lift, lipohypertrophic tissue injection, duration of pen needle in skin, and applied injection force. In addition, we sought to understand the attitudes and behaviours of the physicians caring for these patients with respect to insulin injection technique.

## METHODS

### Study Design and Population

This cross-sectional observational behavioural study consisted of 230 patients and 24 physicians, such as general practitioners and endocrinologists, from across Canada. The

study sample size was not formally determined through statistical analysis and we did not perform a power calculation. This study was a non-interventional, observational study that was developed to gain an understanding of patient-reported insulin injection technique.

To collect feedback on the current state of patient understanding regarding proper insulin injection technique, separate surveys were developed and filled out by the physicians (Supplementary File 1) and patients (Supplementary File 2). All patient surveys were completed in the clinic by the patient. Patients were not asked to indicate their comorbidities. The data from the hard copy forms were then entered into an online platform and database (Vivomap<sup>®</sup>, Mississauga, Canada). Prior to survey launch, usability testing was conducted.

### Inclusion Criteria

Primary care clinics that lack support from diabetes educators were targeted for patient and physician recruitment. To be considered for the study, physicians were required to select non-pregnant patients aged 18 years or older with type 1 or type 2 diabetes injecting insulin using an insulin pen.

### Procedure

Each clinic was asked to complete an initial practice profile survey to gain an understanding of the physician's comfort and level of agreement on the importance of insulin injection technique. The physicians were instructed to, at random, have ten of their patients fill out a survey inquiring about injection practices during a scheduled visit. The physician documented the responses to both the patient survey and practice profile via Vivomap. The patient survey contained a series of questions regarding injection practices. The practice profile survey and the patient injection assessment survey can be found in Supplementary Files 1 and 2, respectively.

### Data Analysis

Data was collected from January to March of 2020 and analysis was conducted using GraphPad Prism and Microsoft Excel. Areas of proper injection technique to be examined were outlined by the study steering committee and in consideration of the FIT recommendations. The injection technique errors that were investigated in the present study include the (1) size of the area of the injection site, (2) length of the needle, (3) duration of the needle in the skin, (4) needle reuse, (5) applied injection force, (6) performance of skin lifts, and (7) injection of insulin into lipohypertrophic tissue. An injection technique error within these categories was defined as follows: patients should use a post-card-sized area to inject insulin, use a 4-mm-length needle, hold the needle in the skin for 10 s or more, and use a fresh needle for each use. Additionally, patient-applied injection force should either have none or slight indentation to the skin. Patients using a 4 or 5 mm insulin pen needle should not perform a skin lift [10]. If a patient experiences lipohypertrophy, they should not inject insulin into the lipohypertrophic tissue.

Correlation matrix multivariate statistical analysis was performed in GraphPad Prism version 8 (San Diego, CA, USA).

### Compliance with Ethics Guidelines

The Injection Technique Practice Reflective study (Pro00040906) protocol was reviewed and approved by the Advarra<sup>®</sup> institutional review board on January 13, 2020 and was conducted in accordance with the principles of the Declaration of Helsinki of 1964 and its later amendments, Good Clinical Practice guidelines, and applicable laws and regulations. Established in 1983, Advarra provides institutional review board (IRB), institutional biosafety committee (IBC), and research quality and compliance consulting services in North America. Written informed consent was obtained from each patient and physician before participation.

## RESULTS

### Physician Characteristics

The 24 physicians recruited for this study were experienced as 83% had been in clinical practice longer than 15 years (Table 1). This group of physicians almost all agreed (23/24) that proper

**Table 1** Physician practice characteristics

	<i>n</i> (%)
Specialization	
Family practice	15 (62)
Specialist	9 (34)
Region of practice	
Ontario	8 (33)
Quebec	8 (33)
East	2 (8)
West	6 (25)
Practice type	
Private	12 (50)
Hospital	2 (8)
Academic	6 (25)
Group	11 (46)
Other	0 (0)
Practice size	
Small	5 (21)
Medium	4 (17)
Large	15 (63)
Years in practice	
< 5	1 (4)
5–9	2 (8)
10–14	1 (4)
15–25	7 (29)
> 25	13 (54)

insulin injection technique was important or very important for improving patient care (Fig. 1a). The majority of the physicians indicated they were completely confident or fairly confident in discussing insulin delivery technique, injection site rotation, and overall technique (Fig. 1b–d). One physician did not engage any patients, and as such there was a total 230 patients enrolled.

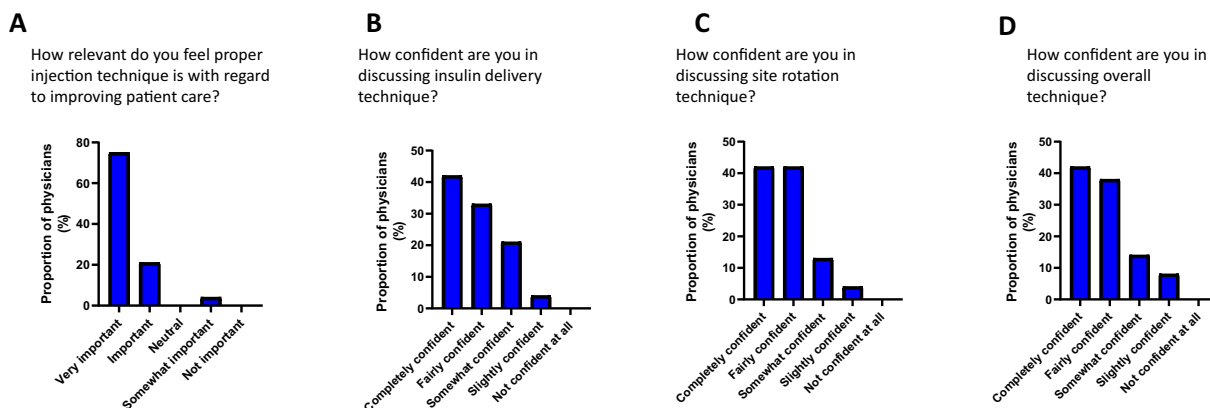
### Patient Characteristics

The characteristics of the patients enrolled in this study were broad in range (Table 2). The average age of the patients was  $61.3 \pm 13.6$  years, the average duration of diabetes was  $16.6 \pm 10.2$  years, and the average glycosylated hemoglobin (HbA1c) was  $7.8 \pm 1.2\%$ . This array of patients is similar to a previous study examining injection practice techniques in the Canadian population [11].

### Patient Self-Injection Behaviour: Injection Site

The most frequently reported self-injection site was the abdomen (Table 3), which is in line with FIT guidelines as the abdomen offers the most consistent absorption of human insulin and a low risk of intramuscular injection [10]. Avoiding intramuscular injection is a critical component of proper insulin injection technique as hypoglycemia and unpredictable blood glucose levels may be associated with intramuscular injection [1, 12, 13]. Although injection site rotation was not explicitly asked for, 61.3% of patients reported only injecting in one site (Table 4). These data may suggest that most patients are not site rotating and site rotation has been associated with optimal glucose control [14].

Following the abdomen, the thigh, then arm, then buttocks were the most commonly used self-injection sites. Although only 12.6% of patients were injecting into the arm, it should be noted that the arm is not a preferred area for self-injection. It is difficult for the patient to assess the correct zone, find the necessary  $90^\circ$  angle, and difficult to pinch up if



**Fig. 1** Physician attitudes and confidence surrounding insulin injection technique patient discussions. **a** Physician attitude toward the importance of proper injection technique on improving patient care. **b** Physician confidence in

discussing insulin delivery technique. **c** Physician confidence in discussing injection site rotation technique. **d** Physician confidence in discussing overall injection technique. Data is expressed as proportion of physicians. *n* = 24

**Table 2** Patient characteristics

Characteristics ( <i>n</i> = 230)	Mean	SD	Minimum	Maximum
Age, years	61.3	13.6	19.0	87.0
Duration of diabetes, years	16.6	10.2	1.0	58.0
HbA1c, %	7.8	1.2	5.9	16.0
Type 1 diabetes, age	61.3	13.6	19.0	80.0
Type 2 diabetes, age	61.4	13.5	39.0	87.0

SD standard deviation, HbA1c glycosylated hemoglobin

needed. In addition there may be less subcutaneous fat on the arm, which may increase the risk for intramuscular injection [1, 15, 16].

**Table 3** Injection site use

	Patients using this site <i>n</i> (%)
Abdomen	215 (93.5)
Thigh	85 (37.0)
Arm	29 (12.6)
Buttock	17 (7.4)
Other	0 (0)

**Patient Self-Injection Behaviour: Area Size of Injection Site**

When patients were asked about the area size they typically inject into, 64% indicated they

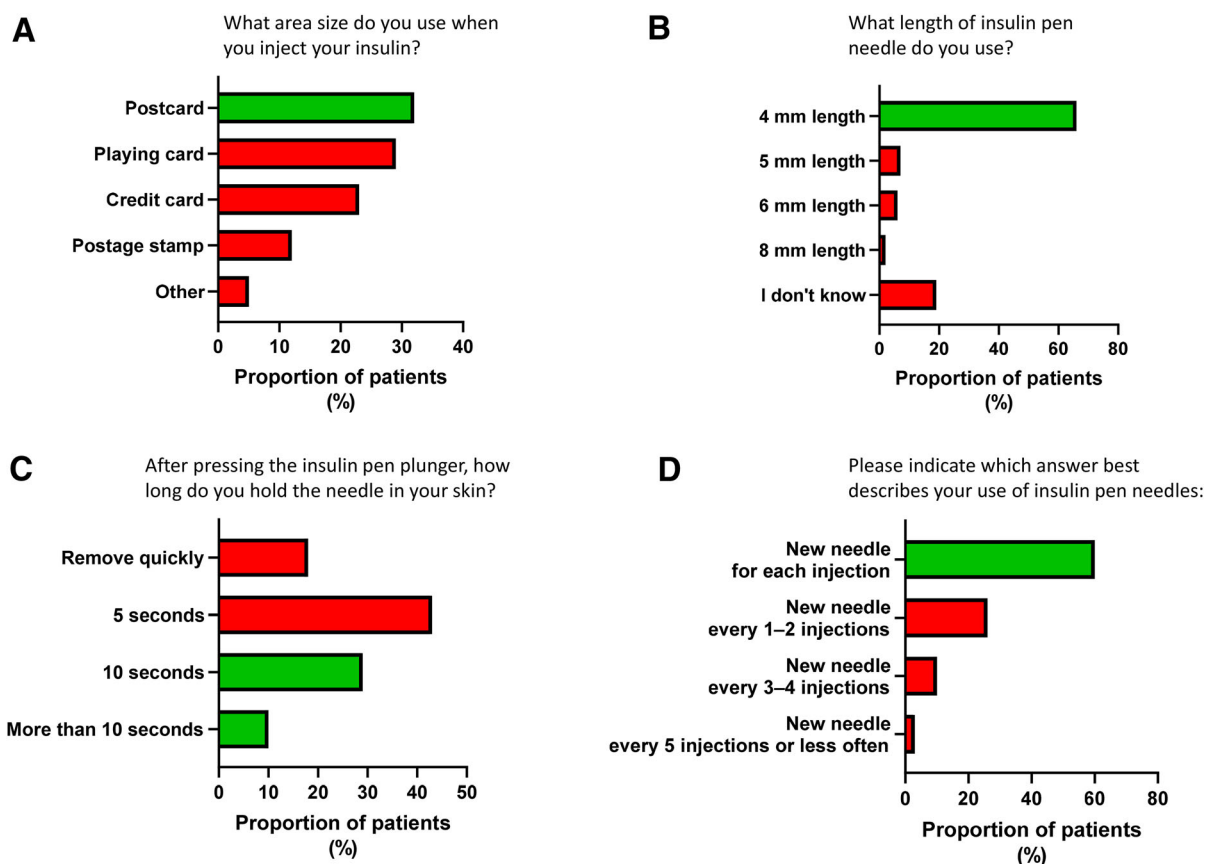
**Table 4** Number of sites used by patients for insulin injection

No. of sites used	Patients using this number of sites <i>n</i> (%)
1	141 (61.3%)
2	65 (28.3%)
3	21 (9.1%)
4	3 (1.3%)

inject into an area smaller than the recommended postcard size (Fig. 2a). Patients should be encouraged to use as large an area as possible in the anatomical area to help facilitate proper injection site rotation. Proper injection site rotation is important for reducing the risk of lipohypertrophy and supporting optimal blood glucose control [17–20]. A previous study examining the impact of site rotation on the risk of lipohypertrophy found that 98% of patients who did not site rotate and/or rotated incorrectly had lipohypertrophy [17]. Lipohypertrophy is also unfavourably associated with increased insulin consumption costs [18].

### Patient Self-Injection Behaviour: Pen Needle Length

The majority of patients (66%) reported using a pen needle of 4 mm, while 19% indicated that they did not know the length of their pen needle (Fig. 2b). A 4 mm pen needle inserted at 90° is long enough to enter the subcutaneous tissue but short enough to reduce the risk of intramuscular injection, and is therefore considered a safe pen needle for adults and children regardless of age, gender, and/or body mass index [21–24]. Additionally, in a prior study patients reported preferring shorter 5 mm pen needles as compared to longer 8 mm needles [25].



**Fig. 2** Patient insulin injection technique behaviours. The green bars represent FIT recommendations on proper injection technique. **a** Area size used when the patient injects insulin. **b** Length of insulin pen used by the patient. **c** Length of time the patient holds the insulin pen needle

in their skin after pressing the insulin pen plunger. **d** Patient insulin pen needle reuse behaviour. Data is expressed as proportion of patients.  $n = 230$



### **Patient Self-Injection Behaviour: Pen Needle Duration in Skin**

Only 39% of patients reported leaving the pen needle in their skin for 10 s or longer highlighting a key patient injection error (Fig. 2c). This may be especially concerning in patients administering higher insulin doses [26, 27]. To increase the probability that the full insulin dose is delivered and to prevent medication leakage, the patient should maintain pressure on the injection button for at least 10 s before withdrawing the needle, or as recommended by the insulin pen manufacturer.

### **Patient Self-Injection Behaviour: Pen Needle Reuse**

Although most patients (60%) did not report reusing insulin pen needles (Fig. 2d), the fact that 40% of those surveyed do reuse needles is important. Pen needles should be used only once to reduce the risk of lipohypertrophy, needle breakage in the skin, infection, inaccurate dosing, and clogging of the needles [1, 4, 8, 28].

### **Patient Self-Injection Behaviour: Applied Injection Force**

The most common patient error in this survey was with respect to applied injection force. Our study found that 76% of patients were applying excess pressure onto the skin when injecting (Fig. 3b). In fact, the most common choice when using Fig. 3a as a reference point was the image depicting the most significant application pressure. Proper technique indicates the needle hub should be visible and to avoid indenting the skin when injecting to reduce the risk of intramuscular injection [5, 29]. Pen needle hub design, in addition to needle length and injection technique, may help with mitigating excessive user-applied injection force [29, 30].

### **Patient Self-Injection Behaviour: Skin Lift**

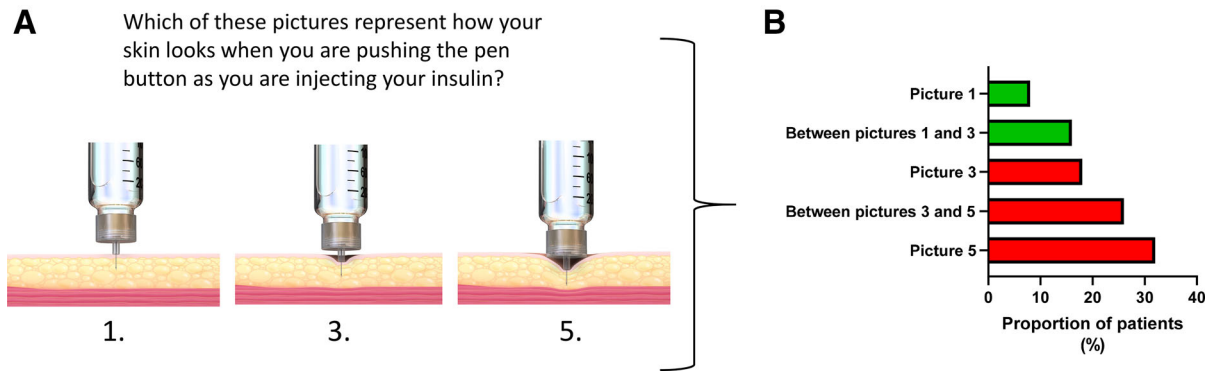
A skin lift may be preformed to reduce the risk of intramuscular injection. Performing a skin lift is not recommended when using 4 or 5 mm pen needles [1, 10]. Of the patients surveyed, 55% reported doing a skin lift (Fig. 4a), and of those performing a skin lift, 69% were using 4 or 5 mm needles (Fig. 4b). Therefore, the majority of patients in this study performing a skin lift were doing so unnecessarily.

### **Patient Self-Injection Behaviour: Lipohypertrophic Tissue Injection**

One-third (33%) of the patients surveyed indicated they have noticed lumps or bumps near injection sites (Fig. 5a), signalling a possibility that lipohypertrophy was present in these patients at some point. Importantly, 37% of these patients indicated they have injected insulin into the likely lipohypertrophic sites (Fig. 5b). Absorption of insulin is impaired in lipohypertrophic tissue, and the risk of hypoglycemia and erratic glucose levels are heightened when insulin is injected into these fibrous and poorly vascularized lesions [1, 20, 31]. Physician training to identify lipohypertrophic tissue has been observed to improve diagnostic accuracy, highlighting a potential role for this type of training in supporting optimal glucose control [32].

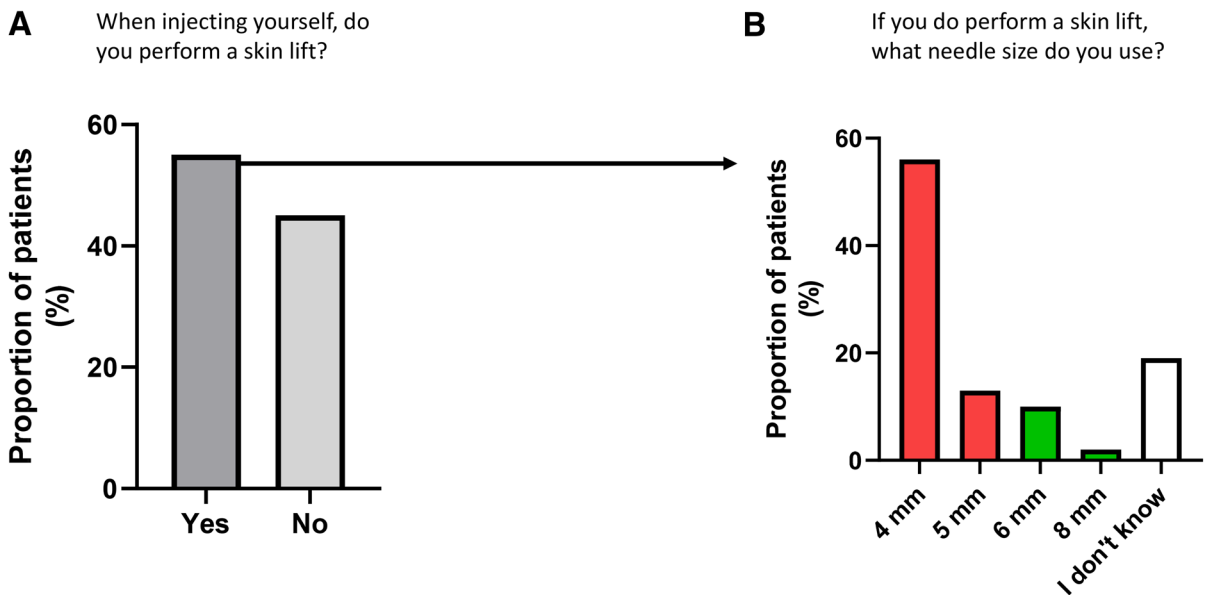
### **Physician Behaviours Surrounding Education of Patients**

From a physician perspective, there is currently no formalized guidance on how often a physician should assess patient injection technique [9, 10]. In the present study, physicians indicated that they most commonly assess insulin patient injection technique on a “when appropriate” basis (Fig. 6a, b). Given the frequency of patient injection errors reported herein, physicians may consider more frequent reviews of their patient’s insulin injection technique or recommend the patient attend injection technique education by clinicians who specialize in diabetes education.



**Fig. 3** Patient-applied injection force behaviours. **a** Visual representation of what a patient’s skin may look like as they push the insulin pen button while injecting

themselves. **b** Proportion of patients who applied the indicated injection force. Data is expressed as proportion of patients.  $n = 230$



**Fig. 4** Patient insulin injection skin lift behaviours. **a** Proportion of patients who perform a skin lift. The green bars represent FIT recommendations on proper injection technique ( $n = 230$ ). **b** Needle size used by

patients who perform a skin lift ( $n = 127$ ). The green bars represent FIT recommendations on proper injection technique. Data is expressed as proportion of patients

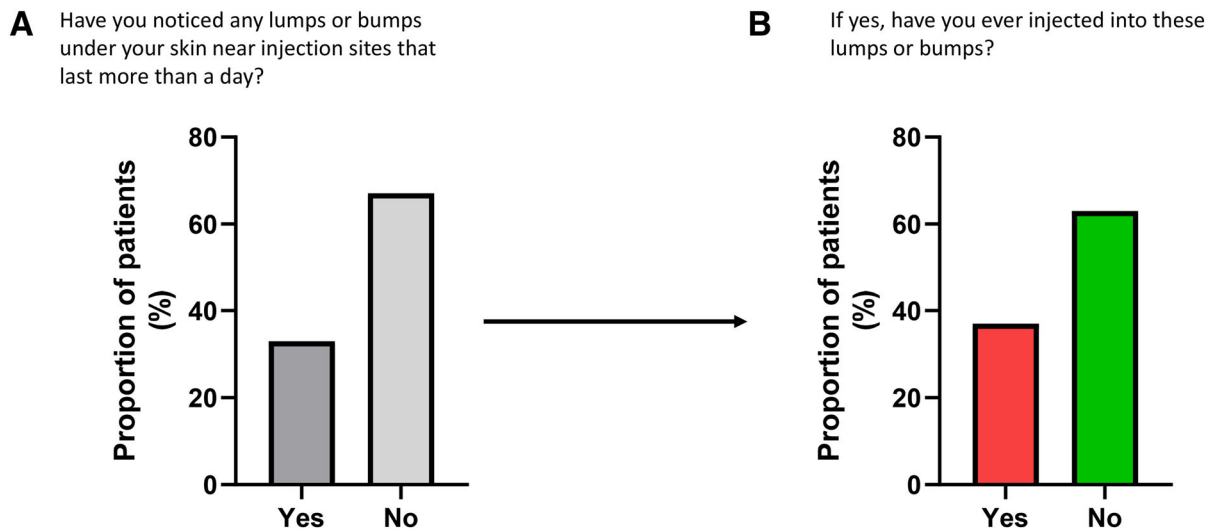
When the physicians were asked to identify the primary barriers to educating patients on insulin injection technique, the most common barrier identified was lack of time followed by lack of personnel support (Fig. 6c). Lack of time and resources are common barriers within the practice of medicine and strategies to overcome these key issues are needed to support proper

insulin injection technique and ultimately improve patient outcomes.

**Correlation Between Number of Errors and Patient Characteristics**

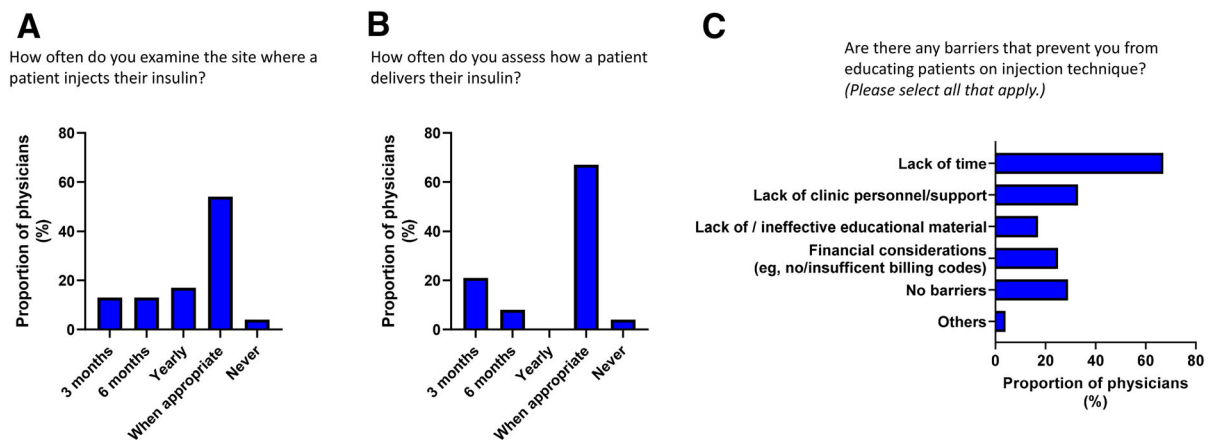
Of the patients surveyed, 5% were making one injection error, 22% were making two errors,





**Fig. 5** Patient-reported lipohypertrophy injection behaviours. **a** Proportion of patients who notice lumps or bumps under their skin near injection sites that last more than a day ( $n = 230$ ). **b** Proportion of patients who have

injected into lumps or bumps ( $n = 76$ ). The green bars represent FIT recommendations on proper injection technique. Data is expressed as proportion of patients

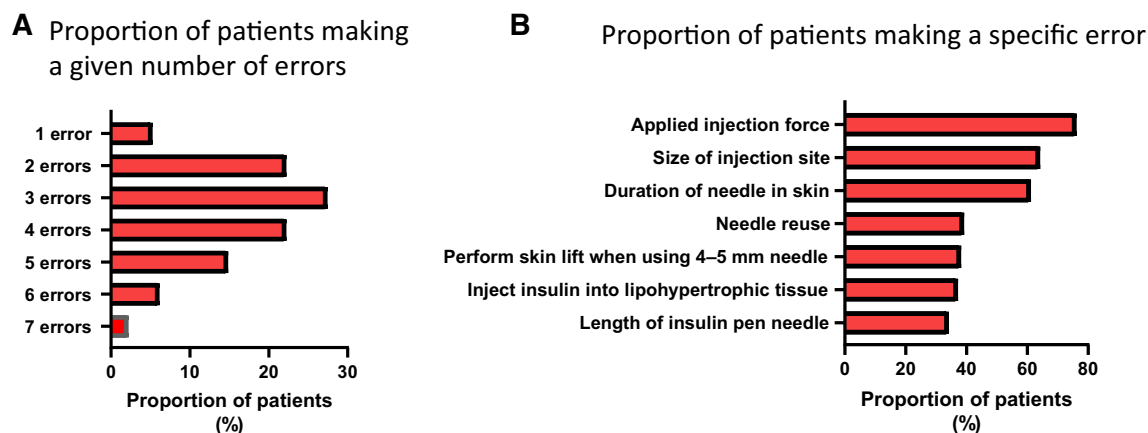


**Fig. 6** Physician behaviours surrounding patient education. **a** Frequency of physicians who examine the site where a patient injects themselves. **b** Frequency of physicians who assess how a patient delivers their insulin. **c** Proportion of

physicians who report barriers preventing them from educating patients on injection technique. Data is expressed as proportion of physicians.  $n = 24$

27% were making three errors, 22% were making four errors, 14% were making five errors, 6% were making six errors, and 2% were making seven errors (Fig. 7a). The average number of insulin injection technique errors a patient was making was  $3.5 \pm 1.4$  within the following categories: applied injection force (76%), area size of injection site (64%), duration of pen

needle in skin (61%), pen needle reuse (39%), performs a skin lift with a 4 or 5 mm needle (38%), uses a longer pen needle than required (34%), and insulin injection into lipohypertrophic tissue (37%) (Fig. 7b). When considering which patient factors correlate with the number of injection errors, there were no significant differences observed when age was



**Fig. 7** Summary of patient insulin injection technique errors. **a** Proportion of patients making a given number of injection technique errors. **b** Proportion of patients

making a specific injection technique error. Data is expressed as proportion of patients.  $n = 230$

stratified by the median, if the patient had type 1 vs type 2 diabetes, or their gender. However, patients being treated in family practice vs a specialist was correlated with the number of injection errors (Table 5). This observation may be related to less access to educational support in the primary care setting compared with the specialist setting.

## DISCUSSION

### Comparison of Findings

The current dataset was collected in Canadian patients with diabetes. A key study for comparison is a 2015 study from Berard and Cameron [11], which examined similar questions in a similar patient population. The largest dataset to compare the present results against is the insulin Injection Technique Questionnaire (ITQ) from Frid et al. conducted between 2014 and 2015, which included 13,289 patients from 423 centres in 42 countries [5]. A study out of China from Ji and Lou in 2010 examining 380 patients across 20 centres is important to compare against as this study was similar in magnitude but in a different geographical location [8].

Injection site preference in the present study was similar to that of Berard and Cameron, Frid et al., and Ji and Lou, as all four study

populations indicated that the abdomen is the preferred injection site (93.5% vs 91.6% vs 90.9%, 93%, respectively). These findings are in accordance with the global FIT guidelines [9].

A skin fold lift was performed at a higher rate outside of Canada as 63.7% of the patients in Frid et al. and 63.2% in Ji and Lou performed a skin lift. In Berard and Cameron, 45.1% of patients performed a skin lift, whereas in the present study 55% of patients reported using a skin lift even though for the majority of these patients a skin lift was likely unnecessary. In Berard and Cameron, only 49% of patients were using 4 or 5 mm pen needles, whereas in the present study, 73% of patients were using 4 or 5 mm pen needles. Considering the 1.5-fold increase in 4–5 mm pen use in the present study vs Berard and Cameron, education surrounding when a skin lift is necessary on the basis of pen needle length appears to be needed in Canada.

In the large global study from Frid et al., 31.9% of the patients surveyed left the needle in the skin for 10 s or longer. In Berard and Cameron, 23.2% of patients reported leaving the needle in the skin longer than 10 s. In the present study, 39% of patients left the needle in the skin for 10 s or longer. The importance of this part of the injection technique is exemplified in Ji and Lou, where 74% of patients reported leaving the pen needle in the skin for 10 s or longer and a positive correlation was observed between the length of time the needle

**Table 5** Correlation matrix between number of errors made and patient factors

	No. of errors vs age < median?	No. of errors vs male?	No. of errors vs type 1?	No. of errors vs family practice?
Pearson <i>r</i>				
<i>r</i>	− 0.1089	0.04486	0.02939	0.2096
95% confidence interval	− 0.2350 to 0.02072	− 0.08499 to 0.1732	− 0.1003 to 0.1581	0.08247 to 0.3300
<i>R</i> <sup>2</sup>	0.01187	0.002012	0.0008639	0.04393
<i>P</i> value				
<i>P</i> (two-tailed)	0.0994	0.4984	0.6575	0.0014
<i>P</i> value summary	NS	NS	NS	**
Significant? (alpha = 0.05)	No	No	No	Yes
Number of XY pairs	230	230	230	230

NS not significant, \*\**P* < 0.05

was kept under the skin and the degree of glycaemic control [8].

With respect to the proportion of patients reusing needles, in the Frid et al. study, 55% were reusing pen needles. In the Berard and Cameron study, 39.3% were reusing pen needles, and the present study observed that 40% of patients reused pen needles. In Ji and Lou, 91.3% of patients reported reusing needles, and it was observed that lipohypertrophy was positively correlated with the frequency of needle reuse [8], similar to previous observations [7, 33].

### Importance of Patient and Physician Education

Proper injection technique education is critical for patients taking insulin. Once a patient is started on insulin, they are rapidly required to self-inject in the absence of healthcare practitioner supervision. In multiple studies, a large number of patient injection errors have consistently been observed [2, 5–8]. Of note, training and education on insulin injection technique has been found to improve HbA1c by approximately 1% [34]. In another study, a multimodal approach to injection technique education was

provided and HbA1c was reduced by 0.58% in patients treated with insulin. This reduction in HbA1c was achieved without weight gain and with less insulin vs controls [35]. Therefore, even though patients may commit numerous insulin injection errors, these patient errors can be rectified with the proper assessment and education, thus producing a positive, clinically relevant outcome. An important consideration is that many patients may require re-training on proper injection technique. Previous work observed that blood glucose control in patients displaying the poorest injection technique improved the most upon re-education [36]. This re-training helps ensure that bad habits are halted and keeps the patient up to date with the latest guideline recommendations. It has been proposed that a reassessment of injection technique should occur every 8–12 months [37]. More specifically, if glycaemic control of a patient is deteriorating after initiation of insulin injection, physicians should check if insulin injection technique is not optimal prior to intensifying therapy. It is important for both patients and physicians to simplify insulin injection technique as much as possible.

As virtual physician visits become more common, it is important to note that patient

training can be done in a virtual setting. The physicians surveyed in the present study were comfortable with insulin injection practices, yet a high percentage of patients are treated by physicians who do not have the same level of experience. In Canada, some primary care networks are moving to share the costs of additional health-care providers, such as diabetes educators and pharmacists, who can perform patient education/re-education on insulin injection technique [38]. Integrating diabetes education teams into primary care may be an ideal approach to supporting physicians and patients in the clinic. Recently, using a historical cohort design at 11 primary care sites across Ontario, Canada, nurse and dietitian diabetes-education teams were observed to have a clinically meaningful impact on the patient's ability to meet recommended HbA1c targets [39]. Considering proper injection technique could hypothetically be taught virtually from almost anywhere with an internet connection, and given the sense that patients are becoming more experienced with virtual visits as a result of the COVID-19 pandemic [40–42], the capacity to involve a broader diabetes management team may be more readily available than ever before.

In addition to virtual training, trustworthy online educational initiatives for asynchronous learning are continually being developed. Directing patients to e-learning resources can provide additional support to the patient regarding their injection technique. For example, the FIT Canada website provides patient educational tools with clear imagery on proper injection technique [10].

### **Role of New-Generation Pen Needle Technology to Support Proper Insulin Injection Technique**

Structured training and the use of new-generation pen needles can help improve injection technique, leading to significant HbA1c reductions and decreased rates of lipohypertrophy [34, 43]. Technological advances in needle

design have observed that a 4 mm pen needle injected at a 90° angle results in optimal needle depth penetration, therefore reducing the risk of intramuscular injections [29]. New-generation pen needles have also been associated with more positive patient reviews and improved ease of use [30], and in general, shorter needles are the preferred choice for most patients [25]. Pen needle hub design may also support proper injection force [29, 30].

### **Study Limitations**

This study was a non-interventional, observational study and was not designed to capture patient outcomes. In the patient survey, the patient was not requested to identify their comorbidities. Diabetes is commonly associated with numerous comorbidities [44], which may have impacted the number of errors being made by patients. Site rotation and pen needle priming are two additional insulin injection technique errors that were not captured. However, considering that all patients were making at least one of the seven errors we assessed, we would not expect our primary conclusion that additional physician and patient education is required to change.

### **CONCLUSION**

The provision of evidence-based FIT recommendations has been vital for supporting proper insulin injection technique. However, patients continue to make errors, suggesting it may be just as important to ensure not only initial education is provided to the patient but also ongoing education. Regular patient assessments of insulin injection technique by the physician may also be important for the implementation of these key recommendations. Solutions to overcome the physician barriers of lack of time and resources surrounding the provision of insulin injection technique education will need to continuously be sought after. The impact of leveraging new technology,

diabetes educational teams, and e-learning are potential avenues to explore in future studies. In addition, incorporating the evidence surrounding patient satisfaction and comparable efficacy with newer, smaller insulin needles in guideline recommendations will be an important concept to consider moving forward.

## ACKNOWLEDGEMENTS

The authors would like to sincerely thank the participants of our study. With this type of study design, patient engagement is crucial to the success of the data collection and resulting manuscript.

**Funding.** Sponsorship for this study and Rapid Service Fee were funded by Becton, Dickinson and Company.

**Authorship.** All named authors meet the International Committee of Medical Journal Editors (ICMJE) criteria for authorship for this article, take responsibility for the integrity of the work as a whole, and have given their approval for this version to be published.

**Disclosures.** Basel Bari reports being a member of an advisory board or equivalent with Novo Nordisk, AstraZeneca, Boehringer Ingelheim, Sanofi, and Eli Lilly. Basel Bari also declares membership of a speakers' bureau with Merck, Novo Nordisk, Sanofi, Boehringer Ingelheim, AstraZeneca, and Eli Lilly. Basel Bari has received or will be receiving a grant or an honorarium from CCRN, Sanofi, Boehringer Ingelheim, and Becton, Dickinson and Company. Marie-Andrée Corbeil reports being a member of an advisory board as a speaker for Novo Nordisk, Eli Lilly, Sanofi, Abbott, Ascensia, Boehringer Ingelheim, Merck, AstraZeneca, Dexcom, and has taken part of an advisory board for Dexcom, Abbott, Novo Nordisk, AstraZeneca, and Amgen. Hena Farooqui, Stuart Menzies, and Brennan K. Smith report that the company they work for, CTC Communications, has received funding from Becton, Dickinson and Company Canada. Brian Pflug reports being

an employee of Becton, Dickinson and Company. Arthur Vasquez reports acting as consultant for Novo Nordisk, Janssen Pharmaceuticals, AstraZeneca, Eli Lilly, and Becton, Dickinson and Company. Arthur Vasquez also received an unrestricted grant from Janssen Pharmaceuticals and has been a paid speaker for Janssen Pharmaceuticals and AstraZeneca. Lori Berard reports receiving honorarium from Becton, Dickinson and Company Canada, Montméd, Sanofi, Novo Nordisk, and Eli Lilly.

**Compliance with Ethics Guidelines.** The Injection Technique Practice Reflective study (Pro00040906) protocol was reviewed and approved by Advarra institutional review board on January 13, 2020 and was conducted in accordance with the principles of the Declaration of Helsinki of 1964 and its later amendments, Good Clinical Practice guidelines, and applicable laws and regulations. Written informed consent was obtained from each patient and physician before participation.

**Data Availability.** The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

**Open Access.** This article is licensed under a Creative Commons Attribution-Non-Commercial 4.0 International License, which permits any non-commercial use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by-nc/4.0/>.



## REFERENCES

1. Frid AH, Kreugel G, Grassi G, et al. New insulin delivery recommendations. *Mayo Clin Proc.* 2016;91:1231–55.
2. Yuan L, Li F, Jing T, et al. Insulin injection technique is associated with glycemic variability in patients with type 2 diabetes. *Diabetes Ther.* 2018;9:2347–56.
3. American Diabetes Association. Pharmacologic approaches to glycemic treatment: standards of medical care in diabetes-2020. *Diabetes Care.* 2020;43:S98–110.
4. Spollett G, Edelman SV, Mehner P, Walter C, Penforis A. Improvement of insulin injection technique: examination of current issues and recommendations. *Diabetes Educ.* 2016;42:379–94.
5. Frid AH, Hirsch LJ, Menchior AR, Morel DR, Strauss KW. Worldwide injection technique questionnaire study: population parameters and injection practices. *Mayo Clin Proc.* 2016;91:1212–23.
6. Strauss K, De Gols H, Hannet I, Partanen T-M, Frid A. A pan-European epidemiologic study of insulin injection technique in patients with diabetes. *Pract Diabetes Int.* 2002;19:71–6.
7. De Coninck C, Frid A, Gaspar R, et al. Results and analysis of the 2008–2009 insulin injection technique questionnaire survey. *J Diabetes.* 2010;2:168–79.
8. Ji J, Lou Q. Insulin pen injection technique survey in patients with type 2 diabetes in mainland China in 2010. *Curr Med Res Opin.* 2014;30:1087–93.
9. The Forum for Injection Techniques (FIT). <http://fit4diabetes.com/>. Accessed 12 May 2020.
10. FIT4Diabetes: FIT Recommendations. <https://www.fit4diabetes.com/canada-english/fit-recommendations/>. Accessed 9 May 2020.
11. Berard L, Cameron B. Injection technique practices in a population of Canadians with diabetes: results from a recent patient/diabetes educator survey. *Can J Diabetes.* 2015;39:146–51.
12. Karges B, Boehm BO, Karges W. Early hypoglycaemia after accidental intramuscular injection of insulin glargine. *Diabet Med.* 2005;22:1444–5.
13. Thow JC, Johnson AB, Fulcher G, Home PD. Different absorption of isophane (NPH) insulin from subcutaneous and intramuscular sites suggests a need to reassess recommended insulin injection technique. *Diabet Med.* 1990;7:600–2.
14. Gentile S, Strollo F, Ceriello A, et al. Lipodystrophy in insulin-treated subjects and other injection-site skin reactions: are we sure everything is clear? *Diabetes Ther.* 2016;15:401–9.
15. Thow JC, Coulthard A, Home PD. Insulin injection site tissue depths and localization of a simulated insulin bolus using a novel air contrast ultrasonographic technique in insulin treated diabetic subjects. *Diabet Med.* 1992;9:915–20.
16. Vora JP, Burch A, Peters HNR, Owens DR. Relationship between absorption of radiolabeled soluble insulin, subcutaneous blood flow, and anthropometry. *Diabetes Care.* 1992;15:1484–93.
17. Blanco M, Hernández MT, Strauss KW, Amaya M. Prevalence and risk factors of lipohypertrophy in insulin-injecting patients with diabetes. *Diabetes Metab.* 2013;39:445–53.
18. Ji L, Sun Z, Li Q, et al. Lipohypertrophy in China: prevalence, risk factors, insulin consumption, and clinical impact. *Diabetes Technol Ther.* 2017;19:61–7.
19. Chowdhury TA. Poor glycaemic control caused by insulin induced lipohypertrophy. *BMJ.* 2003;327:383–4.
20. Famulla S, Hovelmann U, Fischer A, et al. Insulin injection into lipohypertrophic tissue: blunted and more variable insulin absorption and action and impaired postprandial glucose control. *Diabetes Care.* 2016;39:1486–92.
21. Hirsch LJ, Gibney MA, Albanese J, et al. Comparative glycemic control, safety and patient ratings for a new 4 mm × 32G insulin pen needle in adults with diabetes. *Curr Med Res Opin.* 2010;26:1531–41.
22. Gibney MA, Arce CH, Byron KJ, Hirsch LJ. Skin and subcutaneous adipose layer thickness in adults with diabetes at sites used for insulin injections: implications for needle length recommendations. *Curr Med Res Opin.* 2010;26:1519–30.
23. Laurent A, Mistretta F, Bottiglioli D, et al. Echographic measurement of skin thickness in adults by high frequency ultrasound to assess the appropriate microneedle length for intradermal delivery of vaccines. *Vaccine.* 2007;25:6423–30.
24. Bergenstal RM, Strock ES, Peremislov D, Gibney MA, Parvu V, Hirsch LJ. Safety and efficacy of insulin therapy delivered via a 4 mm pen needle in obese patients with diabetes. *Mayo Clin Proc.* 2015;90:329–38.
25. Berard L, Cameron B, Woo V. Pen needle preference in a population of Canadians with diabetes: results



- from a recent patient survey. *Can J Diabetes*. 2015;39:206–9.
26. Broadway CA. Commentary: prevention of insulin leakage after subcutaneous injection. *Diabetes Educ*. 1991;17:90.
  27. Præstmark KA, Stallknecht B, Jensen ML, Sparre T, Madsen NB, Kildegaard J. Injection technique and pen needle design affect leakage from skin after subcutaneous injections. *J Diabetes Sci Technol*. 2016;10:914–22.
  28. Misnikova IV, Dreval AV, Gubkina VA, Rusanova EV. The risks of repeated use of insulin pen needles in patients with diabetes mellitus. *J Diabetol*. <http://www.journalofdiabetology.org/article.asp?issn=2078-7685;year=2011;volume=2;issue=1;spage=2;epage=2;aulast=Misnikova;type=0>. Accessed 11 May 2020.
  29. Rini C, Roberts BC, Morel D, Klug R, Selvage B, Pettis RJ. Evaluating the impact of human factors and pen needle design on insulin pen injection. *J Diabetes Sci Technol*. 2019;13:533–45.
  30. Whooley S, Briskin T, Gibney MA, Blank LR, Berube J, Pflug BK. Evaluating the user performance and experience with a re-engineered 4 mm × 32G pen needle: a randomized trial with similar length/gauge needles. *Diabetes Ther*. 2019;10:697–712.
  31. Johansson UB, Amsberg S, Hannerz L, et al. Impaired absorption of insulin aspart from lipohypertrophic injection sites. *Diabetes Care*. 2005;28:2025–7.
  32. Gentile S, Guarino G, Giancaterini A, Guida P, Strollo F, AMD-OSDI Italian Injection Technique Study Group. A suitable palpation technique allows to identify skin lipohypertrophic lesions in insulin-treated people with diabetes. *Springerplus*. 2016;5:563.
  33. Vardar B, Kizilci S. Incidence of lipohypertrophy in diabetic patients and a study of influencing factors. *Diabetes Res Clin Pract*. 2007;77:231–6.
  34. Misnikova IV, Gubkina VA, Lakeeva TS, Dreval AV. A randomized controlled trial to assess the impact of proper insulin injection technique training on glycemic control. *Diabetes Ther*. 2017;8:1309–18.
  35. Grassi G, Scuntero P, Trepiccioni R, Marubbi F, Strauss K. Optimizing insulin injection technique and its effect on blood glucose control. *J Clin Transl Endocrinol*. 2014;1:145–50.
  36. Nakatani Y, Matsumura M, Monden T, Aso Y, Nakamoto T. Improvement of glycemic control by re-education in insulin injection technique in patients with diabetes mellitus. *Adv Ther*. 2013;30:897–906.
  37. Scain SF, Friedman R, Gross JL. A structured educational program improves metabolic control in patients with type 2 diabetes. *Diabetes Educ*. 2009;35:603–11.
  38. Szafran O, Kennett SL, Bell NR, Torti JMI. Inter-professional collaboration in diabetes care: perceptions of family physicians practicing in or not in a primary health care team. *BMC Fam Pract*. 2019;20:44.
  39. Gucciardi E, Xu C, Vitale M, et al. Evaluating the impact of onsite diabetes education teams in primary care on clinical outcomes. *BMC Fam Pract*. 2020;21:48.
  40. Alromaihi D, Alamuddin N, George S. Sustainable diabetes care services during COVID-19 pandemic. *Diabetes Res Clin Pract*. 2020;166:108298.
  41. Bayer. XARELTO Product Monograph. <https://www.bayer.ca/omr/online/xarelto-pm-en.pdf>. Accessed 14 July 2020.
  42. Romesh Wijesooriya N, Mishra V, Brand PLP, Rubin BK. COVID-19 and telehealth, education, and research adaptations. *Paediatr Respir Rev*. 2020. <https://doi.org/10.1016/j.prrv.2020.06.009>.
  43. Gorska-Ciebiada M, Masierek M, Ciebiada M. Improved insulin injection technique, treatment satisfaction and glycemic control: results from a large cohort education study. *J Clin Transl Endocrinol*. 2020;19:100217.
  44. Iglay K, Hannachi H, Howie PJ, et al. Prevalence and co-prevalence of comorbidities among patients with type 2 diabetes mellitus. *Curr Med Res Opin*. 2016;32:1243–52.