Influence of needle size for subcutaneous insulin administration on metabolic control and patient acceptance

G Kreugel, HJM Beijer, MN Kerstens, JC ter Maaten, WJ Sluiter, BS Boot*

Abstract

Aim: To investigate whether the length of the needle used for intermittent subcutaneous insulin administration affects metabolic control, injection-related side effects and patient preference.

Method: In a crossover study, 68 patients with type 1 and type 2 diabetes, body mass index ≥18 kg/m^2, were randomised into two groups; 52 patients completed the trial. Patients in group A used a 5 mm needle for their insulin injections over a period of 13 weeks, then switched to a longer needle (8 or 12 mm). Patients in group B used the needles in reverse order. Patients were re-assessed at 26 weeks. Primary endpoints were insulin doses, and frequency and severity of hypoglycaemic events. Secondary endpoints were patient preference and frequency of injection-related bruising, bleeding, insulin leakage and pain.

Results: A total of 52 patients completed the study. No change in the mean glycosylated haemoglobin (HbA_{1c}) level was found in group B (baseline, 7.41%; 13 weeks, 7.38%; 26 weeks, 7.34%), whereas a small but significant rise in mean HbA_{1c} level was observed in group A after returning to the longer needle (baseline, 7.67%; 13 weeks, 7.65%; 26 weeks, 7.87%: $p<0.05$). There were no significant changes in the amount of insulin injected, frequency or severity of hypoglycaemic events or insulin leakage in either group. The 5 mm needle was associated with a significant decrease in bleeding, bruising and pain ($p<0.05$). Most patients (86%) showed a preference for the 5 mm needle ($p<0.05$).

Conclusion: For insulin injection, a 5 mm needle length is associated with unchanged HbA_{1c} levels, unchanged frequency or severity of hypoglycaemic events and less discomfort for patients compared with 8 or 12 mm needles. The use of 5 mm needles is as safe as 8 or 12 mm needles. Further research is advisable involving thin and obese patients using 5 mm needles, in order for shorter needles to be recommended as standard practice.

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Key words

Insulin administration; injection devices; needle length

Introduction

In the Netherlands, most people with diabetes who are on insulin therapy inject the drug using an insulin pen and a disposable pen needle. Various studies have shown that correct injection technique is as important to optimal glucose control as the prescribed insulin regimen.[1–4] Good metabolic control reduces the risk of diabetic complications[5,6] but it is unclear whether needle length has any effect on metabolic control. Although the American Diabetes Association recommends injecting insulin into subcutaneous tissue,[7] they do not specify exactly where within such tissue that this should occur. Theoretically, needle length may be of clinical relevance in view of the capillary plexuses situated both superficially in the subcutaneous tissue (directly underlying the dermis) and more deeply between subcutaneous fat and muscle layers.[8] Injecting insulin in the vicinity of the capillary plexuses between fat and muscle layers carries the risk that insulin might be injected directly into muscle, thereby leading to faster resorption and increased risk of hypoglycaemia.[9–12] Hypoglycaemia is an important adverse event with a reported mortality rate of up to 2–4%.[13] Other possible insulin injection-related side effects are pain, bruising, bleeding

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and insulin leakage after needle withdrawal, and lipodystrophy.[14–16] Although using a needle with a smaller diameter was shown to cause less pain than using a larger diameter needle in adults,[17] a study in children showed no difference in pain perception when decreasing the needle diameter from 0.4 to 0.3 mm (27–30G).[18] A study with adults has demonstrated that needle length (6 or 12 mm) had no influence on the pain perception of the patient.[15]

This study was performed to investigate whether the length of the needle used for intermittent subcutaneous insulin administration affects metabolic control, injection-related side-effects and patient preference. Following on from these results, nurses can give adult patients with diabetes mellitus evidence-based advice on which needle length to use when injecting insulin with an insulin pen.

Patients and methods

For this crossover study, patients with type 1 and type 2 diabetes attending the University Medical Centre in Groningen were recruited from the outpatient clinic and randomised into two groups. Group A started using 5 mm needles for insulin administration; group B continued using longer (8 or 12 mm) needles. After 13 weeks, patients in group A returned to the longer needle and those in group B started using the 5 mm needle. After changing to a different needle patients continued injecting in the same injection sites. The 5 mm needle used in this study had an external diameter of 0.25 mm and an internal diameter of 0.12 mm, the 8 mm needle had an external diameter of 0.30 mm, and the 12 mm needle had an external diameter of 0.36 mm.

Male and female adult patients diagnosed with type 1 or type 2 diabetes who had been injecting insulin for one year or more with an insulin pen and a needle length ≥8 mm, were included in the study. Exclusion criteria were: self-adjustments of insulin dosages that were improperly recorded by the patient; glycosylated haemoglobin (HbA_{1c}) levels that showed >15% variation in the year prior to inclusion; patients already using a needle of 5 or 6 mm; hypoglycaemia unawareness; pregnancy or an intention to become pregnant; no effective contraceptive in fertile women; body mass index (BMI) <18kg/m^2; skinfold thickness ≤10 mm at the injection sites (abdomen and thigh); haemoglobinopathies and lipodystrophy.

A table of random numbers was used to determine whether the patient would start in group A or in group B. The study was approved by the Medical Ethics Review Committee and all participants gave their written informed consent.

Variables	Group A	Group B
Gender (M/F)	18/7	16/11
Age (mean±SD)	58.4±14.6	52.8±18.8
Diabetes type (1/2)	11/14	16/11
Body mass index (kg/m^2) (mean±SD)	29.5±5.8	27.0±4.7

Table 1. Baseline characteristics of 52 patients with type 1 and type 2 diabetes, randomly divided between Groups A and B, recruited to a study investigating the length of needle for intermittent subcutaneous insulin administration

Research variables and measuring instruments

Measurements were taken at baseline and after 13 and 26 weeks. The skinfold thickness was measured with Harpenden skinfold callipers (British Indicators Ltd, London). HbA_{1c} was measured by high performance liquid chromatography (Variant II, Bio-Rad, Veenendaal, The Netherlands; reference range: 4.6–6.1%). Insulin doses and the number of experienced hypoglycaemic events were registered at each visit.

The following within-group analyses were undertaken: for group A the measurements at inclusion were compared with the measurements after 13 weeks; for group B the measurements after 13 weeks were compared with the measurements after 26 weeks.

After using the 5 mm needle, patients were asked which needle they preferred, and why. Injection-related side effects (e.g. bleeding, bruising, insulin leakage) were evaluated with the aid of a semi-qualitative questionnaire. The degree of experienced pain was measured using a visual analogue scale (VAS), graded from no pain to worst possible pain. Subjective ratings of pain intensity using the VAS are generally considered valid.[19]

The questionnaire was tested before the start of the study. Four patients were asked to give their opinion on the questionnaire and whether it was understandable. The test patients and two expert nurses examined whether the questionnaire yielded the required information. Their opinion was positive, except for minor criticisms. After adjustments were made, the questionnaire was accepted.

Statistical analysis

A power analysis was based on HbA_{1c} levels. The SD of HbA_{1c} is

HbA_{1c}	Inclusion	After 13 weeks	After 26 weeks
Mean group A	7.67±0.21	7.65±0.22	7.87±0.25
Mean group B	7.41±0.20	7.38±0.17	7.34±0.19
Median group A	7.45	7.55	7.50
Median group B	7.30	7.30	7.50

Table 2. Mean, the standard error of the mean and the median glycosylated haemoglobin (HbA_{1c}) values in 52 patients who completed a study investigating the length of needle for intermittent subcutaneous insulin administration

0.8%. Assuming a correlation coefficient of 0.7 for HbA_{1c} levels repeated after three months when n=49, a difference of 0.25% can be discriminated with a power of 80%. A two-sided p-value <0.05 was considered to be statistically significant. The software SPSS for Windows (version 10.1) was used for statistical analysis. Within-group changes were compared using the Wilcoxon signed-ranks test. Between-group comparisons were made using the χ^2 test and the Mann-Whitney U test. The level of significance for all tests was 0.05.

Results

Out of a total of 68 patients with type 1 and type 2 diabetes recruited from the outpatient clinic taking part, 52 completed the study. Patient characteristics are presented in Table 1. Reasons for discontinuation were: protocol violations (n=3); death (n=2); small bumps developing at the injection site when using the shorter needle (n=2); refusal to resume use of the longer needle (n=4); the pressure needed to depress the plunger of the pen combined with the 5 mm needle was too great (n=1); and lost to follow up (n=4). Of those who completed the study, 49 patients were using an 8 mm needle and three patients a 12 mm needle before inclusion.

There were 25 patients in group A and 27 in group B. Biases through attrition were analysed, comparing those who did and those who did not complete the study. Within-group analyses showed that there were no significant differences in HbA_{1c} levels after using 5 mm needles compared with HbA_{1c} levels after using 8 or 12 mm needles. This did not change after the 12 patients with BMI <25 or the three patients who were using 12 mm needles were excluded. Table 2 shows the mean, standard error of the mean and median HbA_{1c} values for all patients who completed the trial.

Separate within-group analysis of patients in groups A and B showed a significant rise in HbA_{1c} levels (p=0.04) in group A after they returned to using 8 or 12 mm needles.

Between-group analyses were undertaken to detect the possible influence of the sequence. When HbA_{1c} difference values in group A were compared with HbA_{1c} difference values in group B for both intervals, there was no significant difference between the groups after using the 5 mm needle compared with the longer needle, p=0.582 (measurement 2 minus 1) and 0.88 (3 minus 2). To analyse whether there was a change in the difference values of the HbA_{1c} after using the 5 mm needle, between-group analysis showed no significant differences (p=0.6) between groups A and B after using the 5 mm needle. There was, however, a significant rise in HbA_{1c} values in group A compared with group B after using the longer needle (p=0.03). Mean insulin dosages did not change during the study, regardless of whether 5, 8 or 12 mm needles were used.

The majority of patients (86.5%) preferred the 5 mm needle (p<0.05); 7.7% preferred the 8 mm needle; 3.8% preferred the 12 mm needle and 1.9% had no preference. Reasons stated for preferring the 5 mm needle were that it was easier to use (no pinch-up is required), caused less bruises, was less painful or was perceived as being more pleasant to use. Those who answered that it was more pleasant to use were unable to explain why this was the case. Four patients preferred the 8 mm needle, stating that it was more pleasant (n=1), that less insulin was required (n=1), that it caused less pain (n=1); one patient was concerned that insulin delivery would be suboptimal with the shorter needle. Two patients preferred to resume using the 12 mm needle, stating that less force was required (n=1) and that less pain was experienced (n=1).

Significantly more bleeding (p<0.05), bruising (p<0.05), and pain (p<0.05) were reported when using the longer needle compared with the shorter needle. There was no significant difference in reported leakage of insulin or frequency of hypoglycaemic events when injecting with the 5 mm needle compared with the longer needle.

Discussion

In this crossover study we demonstrated that using a 5 mm needle without pinch-up when injecting insulin had no negative influence on glycaemic control, as assessed by HbA_{1c} levels and compared with insulin injections using a longer needle and with pinch-up.

We observed a group effect in this study. There was a significant increase in HbA_{1c} levels in group A patients, who used the 5 mm needle in the first period and returned to longer needles in the second period

(p=0.04). One possible explanation is that the stress experienced when having to return to using a longer needle might have influenced HbA_{1c} levels; the number of patients (86%) who preferred the 5 mm needle would seem to support this. Another explanation is that the longer needle caused more injection-related skin trauma, which may have adversely affected insulin absorption.

Reasons stated by patients for preferring the 5 mm needle were that the technique was easier (since pinch-up was not necessary), it caused less pain and less bruising, and was perceived to be more pleasant. Difference in needle length, diameter and coating, and seeing the needle may influence the perception of pain. The results of an earlier study[15] into 6 mm versus 12 mm needle lengths, in which people did not know which needle length they were using, showed that needle length had no influence on pain perception. The findings of the present study disagree with this. If perceived pain is greater when seeing a longer needle, and since patients injecting themselves in daily practice are aware of needle length, it is important to take this into consideration when advising patients.

Although the results of our study support those of Van Doorn *et al*,[15] who showed there were no significant differences in insulin leakage between 6 mm needle and 8 mm needles, our findings did not support those of studies which indicate that patients using shorter needles experienced fewer hypoglycaemic events.[9–12] A limitation of the present study is that although patients had been asked to record hypoglycaemic events in their diary, when the questionnaire was given it appeared that few patients had remembered to do this, so their answers were memories biased by time.

Another limitation was that patients were given a questionnaire at the end of the study in order to compare the 5 mm needles with longer needles. In retrospect, it would have been better to have given a questionnaire to both groups at the start of the second measurement, when they had just finished using one needle, and then again at the end of the study when they had just finished using the other needle. This would have avoided the bias caused by the comparison of a recently experienced event with an event experienced three months earlier. Thus, this would have strengthened the reliability of the results.

Two patients out of a total of 68 (including drop-outs) who preferred the 12 mm needle said that less force was needed to depress the plunger of the pen with the longer needle. Two patients reported the occurrence of little bumps (like mosquito bites) when using the 5 mm needle, and it is possible that the insulin was injected intradermally. Study results suggest that insulin injected intradermally may act faster than insulin injected subcutaneously.[20,21]

Recommendations for nursing and medical practice

The results of this study are not strong enough to recommend that the 5 mm needle should be used as standard practice. For insulin injections, 5 mm long needles are associated with unchanged HbA_{1c} levels, unchanged frequency or severity of hypoglycaemic events and reduced discomfort for patients compared with 8 or 12 mm needles. Although our study findings cannot be interpreted to mean that thin patients can always safely use 5 mm needles, their use is as safe as using 8 or 12 mm needles in patients with a BMI ≥18 and a skinfold thickness >10 mm.

Patients just starting to inject insulin should receive information about the various needle lengths available and the needles produced by different companies. They should be told that if they experience problems when injecting insulin they should investigate whether using a different needle might alleviate the problems. Further research is advisable into thin and obese groups, using 5 mm needles, to establish standardised advice recommendations.

Conflict of interest:

None

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