

Effect of Reuse of Insulin Needle on Glycaemic Control and Related Complications in Children with Type 1 Diabetes Mellitus: A Prospective Observational Study

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Abstract

Background: Children with type 1 diabetes (T1D) take multiple subcutaneous injections of insulin daily to survive. It is controversial whether the insulin needles can be reused safely or not. This study assesses the effect of the reuse versus single-use of insulin needle on glycaemic control and injection-related complications. **Methods:** Nearly 121 children (<15 years) with T1D were prospectively observed for existing practice of needle reuse for first 3 months and then were asked to practice single-use for the next 3 months. **Results:** It was found that 78% participants were reusing needles more than three times. After 3 months of needle reuse, 91.3% patients had lipodystrophy. Frequency of reuse positively correlated with local redness, bleeding and leakage of insulin. The patients achieving HbA1c $\leq 7.5\%$ was significantly low among those reusing needles more than four times. After 3 months of single-use, no significant difference was found in mean HbA1c. However, hyperglycaemic episodes, lipodystrophy and local complications reduced significantly. There was a significant reduction in mean HbA1c among those using needles more than six times earlier. **Conclusion:** Reuse of insulin needles up to six times does not affect the glycaemic control significantly. To achieve target HbA1c (<7.5%) the needle reuse should be restricted to three times only, which can also reduce injection-related local complications.

Keywords: Children, glycaemic control, insulin, lipodystrophy, needle reuse, type 1 diabetes

INTRODUCTION

Type 1 diabetes (T1D) is an endocrine disorder commonly diagnosed during childhood, which mandates multiple subcutaneous injections of insulin for optimal glycaemic control everyday.^[1] Although the needles used are disposable and for one-time use, the financial constraints and other personal reasons often lead to reuse of these needles among people with T1D.^[2] Reuse of needle deforms it which leads to local complications at the injection site like lipodystrophy, bleeding and infection.^[3,4] Lipodystrophy often leads to variable insulin absorption and action, causing aberrant glucose records and poor glycaemic control.^[3,5] Reuse of needles also raises the risk of infections like *Staphylococcal epidermis*.^[6] Needle reuse is also associated with increased pain perception during the injection.^[7] So, it is often suggested to totally avoid reusing needles.^[8] On the one hand, the needle manufacturing companies recommend that insulin needle

be used only once to guarantee sterility. On the other hand, there are studies reporting that reuse of needles is safe and cost-effective^[9,10] or have reported a need for future studies to establish the safety of needle reuse.^[11] Also, the East African Diabetes Study Group (EADSG) has stated that reuse of needles among patients with diabetes should not be highlighted as a risk for excessive morbidity.^[12] The American Diabetes Association (ADA) has a rather practical approach on needle

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reuse. It recommends that do not reuse needle if the patient has any comorbidity, lowered immunity, open wounds on hands or poor personal hygiene. Further, it also recommends discarding the needle if it appears to be deformed, blunt, or has come in contact with any surface other than skin.^[13] So, this lack of consensus about effect of needle reuse on local complications and glycaemic control warrants further quality research especially among children with T1D. This study was conducted to evaluate the effect of insulin injection needle reuse on glycaemic control and injection-related complications among children with T1D. The other objective of this study was to determine the number of times an insulin injection needle can be used safely (i.e., without any significant complications).

MATERIAL AND METHODS

A prospective, observational cohort study was conducted at a tertiary level pediatric hospital in North India from March 2017 to June 2018. The *Institute Ethics Committee* approved the study protocol (INT/IEC/2017/144 dated 27 February 2017). Children and adolescents (<15 years), with T1D for at least 6 months, under regular follow-up, on basal-bolus insulin regimen using insulin analogues, taking at least three multiple daily insulin injections via insulin pen were included in the study. Children with any known primary or secondary immune deficiencies or skin infection were excluded from the study. A written informed consent from the parents/caregivers, and assent from the children, was obtained before enrollment. Demographic data, baseline information like the duration of diabetes, type of insulin therapy, number of injections per day, insulin dose in units/kg/day, percentage of hyperglycaemic and hypoglycaemic records over the previous 3 months, HbA1c levels, and injection-related complications were collected at the time of enrollment.

To analyse how many times a needle can be used safely without significant complications, the patients were divided into four groups according to the number of times they reused the insulin needles, that is, up to three times, four to six times, seven to nine times and ten times or more. To detect a mean HbA1c difference of 0.5% with SD of 1.5% (as per previous study),^[14] a sample size of 97 was calculated considering an alpha error of 5% and power of 90%. Considering an attrition rate of 20%, a total of 121 patients were enrolled.

At the time of enrollment, patients were assessed for their practice of injection technique, needle reuse and site rotation. Information was also collected about the storage practice of insulin injections and syringes, complications of insulin injections like pain, lipodystrophy, bleeding, leakage at site (defined as occurrence of these events with any needle prick) and infection. After the baseline assessment, they were advised to continue their existing practice of needle reuse for the first 3 months. After this 3-month period, assessment was done again at first follow-up. Following this, the participants were provided free insulin pen needles (BD Ultra-Fine™ III 4 mm/32 G). They were advised to continue their existing

injection-related practices except for a single-use of insulin needle for the next 3 months. At the end of 6 months (3 months of single-use of needles), second follow-up assessment was done to assess the effect of using a needle only once. The patients were also advised to bring back used needles during follow-up in a hard leak-proof plastic bottle which were disposed using hospital biomedical waste management system. Collection and disposal of insulin needles (in hospital) also ensured a check on compliance on single-use of insulin needles over the 3 months. The data were collected at the baseline, 3 and 6 months were compared to study the effect of reuse and single-use of insulin injection needles among the four groups (based on the frequency of needle reuse in first 3 months of the study).

For the purpose of this study target HbA1c, hypoglycaemia and hyperglycaemia were defined as per International Society for Pediatric and Adolescent Diabetes (ISPAD) guidelines for resource limited settings.^[15] An HbA1c value <7.5% was taken as optimal glycaemic control.^[15] Insulin leakage was defined as insulin drops oozing out from the injection site during or after injection. Lipodystrophy was described as a localized hypertrophy of the subcutaneous fat at the insulin injections site. It was graded as follows^[16]: Grade 0 – no changes, Grade 1 – visible hypertrophy of fat tissue (on inspection) but with normal consistency of fat tissue (on palpation), Grade 2 – intensive fat tissue thickening with firm consistency, Grade 3 – lipoatrophy. The pain perception was assessed by “Wong-Baker Faces Pain Rating Scale”.^[17]

The data was entered and analysed using the Statistical Package for Social Sciences (SPSS) for Windows (Version 20.0, Armonk, NY: IBM Corp). Continuous variables like HbA1c, percentage of hyperglycaemic records, percentage of hypoglycaemic records, total daily dose of insulin and pain scores were compared using the Wilcoxon signed rank test. The nominal variables like lipodystrophy, redness, bleeding and ecchymosis at injection sites were compared using the Chi-square test. Correlation between needle reuse/single-use and various disease-related parameters was assessed using the Pearson’s correlation coefficient for continuous variables and lambda correlation for the nominal variables. A *P* value of <0.05 was considered statistically significant.

RESULTS

A total of 121 children were enrolled out of which, 102 completed their first follow-up at 3 months and 91 completed their second follow-up at 6 months [Figure 1]. The mean (SD) age of children at enrollment was 7.7 (3.87) years (range 2.2–15 years), and 71 (58.7%) of them were boys [Table 1]. The median (interquartile range [IQR]) duration of diabetes was 17 (21) months.

At baseline, the mean (SD) HbA1c was 8.59% (2.55) and mean (SD) body mass index (BMI) Z score (kg/m²) was 0.79 (1.36). Regarding the insulin injection practices, 119 (98.3%) of the participants were storing the insulin pen

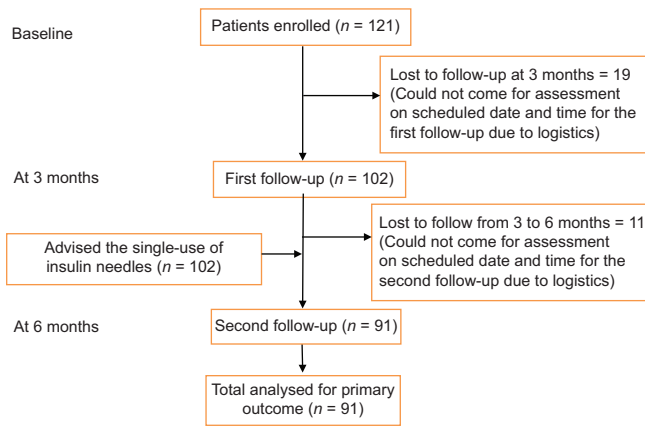


Figure 1: Study flow diagram

and needle in the refrigerator, 103 (85.1%) applied alcohol before injection, 34 (28.1%) stored the lancet in refrigerator and 23 (19%) removed needle from the pen after every use. Five injection sites used were left arm, right arm, left thigh, right thigh and abdomen. Only 94 (78%) participants were using three or more sites for injecting insulin. At enrollment, 36 (29%) of the participants were reusing the needles up to three times, 49 (40.5%) were reusing the needles four to six times, 23 (19%) reused the needles seven to nine times, and 10% were reusing the needles ten times or more.

Analysis at 3 months follow-up (period of insulin needle reuse)

Out of the total, 102 completed the first follow-up after 3 months of continuing their needle reuse practice. Lipodystrophy was seen in 93 (91.1%) of the participants [Table 2].

At 3 months, the percentage of hyperglycaemic records significantly correlated positively with the frequency of needle reuse ($r = 0.251$; $P = 0.011$). Further, there was a significant positive correlation between frequency of needle reuse and local complications, namely, redness ($r = 0.625$; $P = 0.000$), bleeding at site ($r = 0.488$; $P = 0.000$) and leakage during insulin injection ($r = 0.249$; $P = 0.012$).

Analysis at 6 months follow-up (after a 3-month period of single-use of insulin needle)

Primary outcome was change in various glycaemic control parameters at 3 and 6 months follow-up. Mean (SD) HbA1c (%) at the time of enrollment was 8.59 (2.55), at the end of the 3 months was 7.95 (1.69) and at the end of 6 months was 7.80 (1.45). On subgroup analysis, a significant reduction ($P = 0.000$) in HbA1c level was observed with introduction of single-use of needle, among patients who were reusing needles more than six times [Table 3]. However, there was no statistically significant difference in mean HbA1c at 3 and 6 months when all the participants were analysed [Table 2]. Amongst all glycaemic control-related variables, significant improvement was seen only in percentage of hyperglycaemic records.

In Figure 2, we have compared the proportions of patients achieving target HbA1c <7.5% in the four subgroups at 3 and

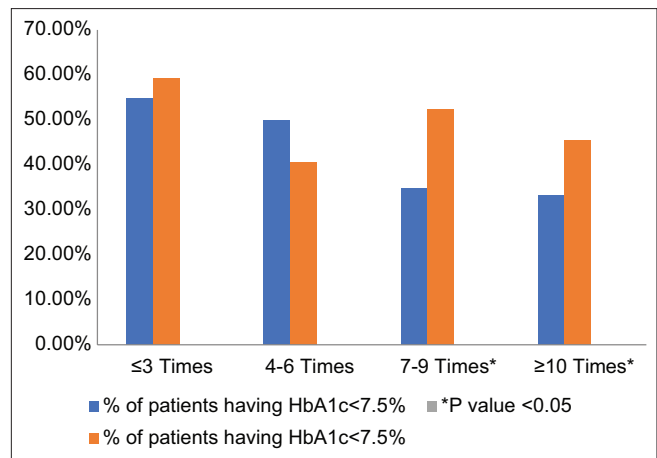


Figure 2: Percentage of subjects having HbA1c <7.5% at 3 and 6 months in four subgroups as per frequency of needle reuse

Table 1: Demographic and glycaemic control parameters details of the children with T1D at enrollment (n=121)

Baseline Parameters	Value (Mean ± SD)*
Age (years)	7.77±3.87
Age at diagnosis (years)	5.60±3.70
Gender (%)	
Male	71 (58.67%)
Female	50 (41.33%)
Median (IQR) duration of diabetes (months)	17 (21)
Mean weight for age (Z score)	0.22±1.43
Mean height for age (Z score)	-0.17±1.75
Mean BMI (Z score)	0.79±1.36
HbA1c (%)	8.59±2.55
Insulin dose (U/kg/day)	1.13±0.66
Percentage of high glucose records#	25.56±12.6
Percentage of low glucose records#	10.11±7.80
Distribution of lipodystrophy as per frequency of needle reuse ("n" with lipodystrophy/total in the subgroup):	
≤3 times	27/36 (75%)
4-6 times	43/49 (87.75%)
-9 times	20/23 (86.95%)
≥10 times	13/13 (100%)

*Except for duration of disease in months; #Out of all sugar records in last 1 month

6 months. In the subgroups of patients reusing needles up to three times and four to six times, there was no significant difference ($P = 0.73$, $P = 0.43$, respectively) in the number of participants achieving an HbA1c <7.5%. But, in the other two subgroups reusing needles seven to nine times and more than 10 times, significantly lower number of participants had an HbA1c <7.5% at 6 months.

Lipodystrophy showed a significant improvement when compared between 3 and 6 months. Frequency of lipodystrophy of different grades and other complications at different time points in the study is shown in Table 2. There was a significant decrease in occurrence of bleeding at injection site ($P = 0.000$), leakage of insulin while injecting ($P = 0.003$) and pain

Table 2: Percentage and frequency of various complications related to insulin injections and glycaemic control parameters at enrollment and follow-up

Complications		At Enrollment (n=121) Number (%)	At 3 months (n=102) Number (%)	At 6 months (n=91) Number (%)	P*
Lipo-dystrophy Grade	None	18 (14.86)	9 (8.82)	19 (20.87)	<.001
	1	43 (35.54)	33 (32.35)	61 (67.03)	<.001
	2	50 (41.33)	49 (48.04)	11 (12.08)	<.001
	3	10 (8.26)	11 (10.78)	0	<.001
Lipodystrophy at injection site (any grade)		103 (85.12)	93 (91.17)	72 (79.12)	<.001
History of bleeding at injection site		30 (24.79%)	37 (36.27%)	3 (3.3%)	0.000
Leakage of insulin while injecting		21 (17.36%)	27 (26.47%)	1 (1.09%)	0.003
Ecchymosis at injection site		7 (5.78%)	10 (9.8%)	1 (1.09%)	0.002
Mean pain score at last use of needle ^e		6.11±2.32	6.00±1.89	-	-
Mean pain score at use of fresh needle ^e		2.24±1.91	2.28±1.90	1.84±1.56	0.061 [‡]
HbA1c (%)		8.59±2.55	7.95±1.69	7.80±1.45	0.560 [‡]
Insulin dose (U/kg/day)		1.13±0.68	1.14±0.69	1.35±0.67	0.317 [‡]
Percentage of high blood glucose*		25.56±12.6	23.64±11.21	20.67±11.86	<0.001 [‡]
Percentage of low blood glucose records*		10.11±7.80	11.65±6.60	9.77±5.5	0.461 [‡]

[†]Chi-square test between 3 and 6 months; *Out of all glucose records in last 1 month [‡]Wilcoxon signed ranks test between 3 and 6 months; ^eExcluding 11 children <3 years

Table 3: Subgroup analysis of patients for mean HbA1c at 3 and 6 months (as per frequency of needle reuse)

Number of times needles are reused	HbA1c at 3 months (Mean + SD)	HbA1c at 6 months (Mean + SD)	P*
≤3 times (n=27)	7.54±1.32	7.41±1.27	0.501
4–6 times (n=32)	7.91±1.96	8.17±1.74	0.332
7–9 times (n=21)	8.78±1.62	7.65±1.24	0.000
≥10 times (n=11)	9.89±1.31	8.00±1.15	0.000

*Wilcoxon signed ranks test

score ($P = 0.001$) with single-use of needles. Out of 60 patients having grade 2 or 3 lipodystrophy, only ten patients had grade 2 lipodystrophy after 3 months of single-use of insulin needle, and none had grade 3 lipodystrophy [Table 2].

We performed subgroup analysis (as per frequency of needle reuse) for various injection-related complications at 3 and 6 months [Table 4]. There was a significant reduction in proportion of patients having redness, bleeding, and insulin leakage after the injection, following single-use of insulin needles, among those who were reusing insulin needle more than 3 times. The occurrence of lipodystrophy was significantly low only in the subgroup reusing needles ten times or more. However, there were no differences in the occurrence of ecchymosis among the subgroups.

DISCUSSION

In this prospective observational study, the mean HbA1c was significantly lower after 3 months of single needle use in the participants using insulin needles more than six times. Further,

a significantly greater number of patients achieved HbA1c target (7.5% or low) after 3 months of single-use of insulin needles among those reusing needles more than six times. The results suggest that an insulin pen needle can be used safely up to six times without affecting the glycaemic control. Also, local complications namely, redness, leakage of insulin and bleeding at the injection site are significantly reduced when reusing a needle up to three times. This study also revealed that percentage of hyperglycaemic records reduced after single-use of needle. This can be related to the improved insulin penetration and absorption due to lesser lipodystrophy and insulin leakage at site as evident by the study results.

Lipodystrophy was found to be higher (85.6%) in our study as compared to previous studies (15.9–50%).^[3,18-20] There could be few reasons behind this observation. First, this study included only the children who were reusing insulin needles; and frequency of needle reuse was high, as 76% participants were using a needle more than three times. Second, the definition of lipodystrophy is not uniform in various studies. In this study, grade 1 lipodystrophy (apparent swelling of the fat but normal on palpation) was also included, unlike few previous studies,^[5,6,12] which could have resulted in higher proportion of lipodystrophy in the study results. Although, the overall occurrence of lipodystrophy significantly reduced after single-use of insulin needle, there was no difference in subgroup analysis based on frequency of needle reuse (except for those reusing needles more than ten times). This indifference among subgroups could be related to other important factors like injection site rotation which was not assessed objectively in our study. So, we could not deduce the safe number of needle reuse which could significantly reduce the occurrence of lipodystrophy.

The mean pain score at first/fresh use of insulin needle tended to be lower at 6 months follow-up compared to baseline

Table 4: Subgroup analysis of patients for various injection-related complications at 3 months and 6 months (as per frequency of needle reuse)

Complications	Time-points	Subgroups as per needle reuse			
		≤3 times	4-6 times	7-9 times	≥10 times
Redness at injection site	3 months	3/31 (9.67%)	13/36 (36.11%)	19/23 (82.6%)	11/12 (91.66%)
	6 months	0/27 (0%)	1/32 (3.1%)	0/21 (0%)	2/11 (18.18%)
	<i>P</i> value [#]	0.240	0.0007	0.0001	0.0002
Ecchymosis at injection site	3 months	2/31 (6.45%)	4/36 (11.11%)	1/23 (3.84%)	3/12 (25%)
	6 months	1/27 (3.70%)	0/32 (0%)	0/21 (0%)	0/11 (0%)
	<i>P</i> value [#]	1.0	0.11	1.0	0.21
Bleeding at injection site	3 months	3/31 (9.67%)	12/36 (33.33%)	12/23 (46.15%)	10/12 (83.33%)
	6 months	1/27 (3.70%)	1/32 (3.1%)	0/21 (0%)	2/11 (18.18%)
	<i>P</i> value [#]	0.615	0.0016	0.0001	0.0012
Leakage of insulin while injecting	3 months	1/31 (3.22%)	13/36 (36.11%)	10/23 (43.47%)	3/12 (25%)
	6 months	0/27 (0%)	1/32 (3.1%)	0/21 (0%)	0/11 (0%)
	<i>P</i> value [#]	1.0	0.0007	0.0006	0.217
Lipodystrophy at injection site (any grade)	3 months	25/31 (80.64%)	35/36 (97.22%)	21/23 (91.30%)	12/12 (100%)
	6 months	17/27 (62.96%)	27/32 (84.37%)	17/21 (80.95)	8/11 (72.72%)
	<i>P</i> value [#]	0.153	0.0923	0.402	0.0014

[#]Fisher's exact test

and 3 months. Although this difference was not statistically significant, it could be related to psychological or time-related lowered pain threshold over the study period.

There is scarcity of studies assessing the ill-effects of needle reuse among patients with T1D, especially among children. A multinational survey of 4532 adult patients including T1D and T2D from 16 countries by De Coninck *et al.*^[19] has shown that insulin needle reuse can have a significant effect on the lipodystrophy similar to the results of this study. The study results are also similar to another study by Vardar *et al.*^[4] that reported lipodystrophy to be 20.3%, 51.2%, 75% and 100% among those who used the needle, only once, two to three times, four to five times, and till the cartridge lasts, respectively. Lipohypertrophy has been reported to be associated with the disease duration, length of the needle, duration of insulin therapy, lack of site rotation, and poor glycaemic control.^[20] This is further supported by the results of our study.

A few participants reported their concern behind reusing the insulin pen needles. According to them, priming a new needle every time and giving an air shot of one or two units of insulin as recommended results in insulin wastage. This concern was raised by significant number of participants after single-use of insulin needle for 3 months. This means that the change of needle every time increases not only the cost of needles but also the cost of insulin leading to double financial burden.

The major strength of this study is that it tried to answer a very relevant clinical question about how many times an insulin needle can be reused safely without any significant effect on glycaemic control and occurrence of injection-related complications. This question is very important for low-income countries where each new needle adds to the already substantial cost of insulin and glucose testing for children with T1D. Another strength of the study is that it followed the same cohort

of patients prospectively for 3-month intervals of multiple use and single-use of insulin needles consecutively. This study design is expected to avoid all other confounding variables, which could affect the glycaemic control among these children.

However, there are few limitations to this study like the lack of randomization and lack of evaluation of long-term impact of needle reuse on glycaemic control and local complications. In our view, it was difficult to advise reusing needles to a patient who was using needle only once and randomised to multiple use of needles (if randomisation was done). We overcame this lack of randomisation by having patients serve as their own control, in two periods of 3 months each (before and after intervention of single-use of insulin needles). As the patients with at least 6 months of diabetes duration were enrolled, the possibility of some patients having partial remission phase cannot be ruled out. This could have affected the glycaemic control and thus confounded the effect of single-use of insulin needles. However, during the period of 6-month follow-up none of our patients went into remission, likely because very few patients had diabetes duration below 1 year. Further, the attrition rate in our study (91 out of 121 enrolled subjects completed the 6-month follow-up; attrition rate of 24.8%) was more than anticipated 20%. However, the power of the study should still be >80% as the sample size calculated for 80% power comes out to be 75.

Future studies should build on this work and randomised studies with longer follow-up periods can further support the study findings. Cost-effectiveness analysis of single-use versus reuse of needle considering the insulin lost in priming and cost of insulin needles on one hand and long-term improved glycaemic control on another, is also warranted in future.

The study results have two major implications. First, there is no effect in the glycaemic control when a needle is used up

to three times (as patients reusing needles up to three times were more likely to achieve target HbA1c). It is, therefore, recommended that in our clinical setting keeping in mind the cost of needles, the insulin needles could be used up to three times without affecting their glycaemic control, although the single-use of insulin needle is always better for those who can afford. However, proper handling and storage of the insulin needles with strict asepsis needs to be determined. Second, lipodystrophy, pain, bleeding and leakage at the injection site are common among patients reusing insulin needles and can be significantly reduced with not using a needle more than three times.

CONCLUSION

Reuse of insulin injection needles in patients with T1D is a common practice especially in the developing countries like India. Based on the results of this study it can be concluded that reuse of insulin needles up to six times does not affect the glycaemic control significantly. Further, to achieve target HbA1c (<7.5%) insulin needle should not be reused more than three times. Also, the complications related to insulin injections significantly decrease if the insulin needles are not reused more than three times.

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Conflicts of interest

There are no conflicts of interest.

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