

## Needle free versus needle insulin injection on pain sensation among type 1 diabetic children in Saudi Arabia

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**Abstract:** The needle free insulin injection is recently used to administer insulin injections to patient suffering from diabetes. Insulin administered by needle free jet injectors is dispensed over a larger subcutaneous area than insulin injected with a syringe, which may facilitate a more rapid absorption. The aim of the study is to investigate the needle free versus needle insulin injection on pain sensation among type 1 diabetic children. Randomized control clinical trial design was used in this study. This study was conducted in the Pediatric Diabetes Clinic at King Fahad Hospital of University, University of Dammam in Al Khobar city. Systematic random sampling of 30 children who have type 1 DM and their mothers were selected from the previous mentioned setting. Subjects were divided into two homogenous groups, 15 children for each group, control and study groups. Control group received the hospital routine of insulin therapy (needle insulin injection), while study group received needle free insulin injection. Two tools were used in this study to assess the studied children's pain intensity, faces pain scale (for children aged 3 to 7 years) and numerical rating scale ((for children aged 7 years and above). One session of interview for every child and his mother in study group was carried out by the researcher to train them about the needle free insulin injection. The session was done immediately before the use of needle free insulin injection, and its time ranged from 45-60 minutes. In follow up [after 3months of using needle free insulin injection], the researcher assessed the children's pain intensity before and during the insulin administration therapy by using the study tools. The results of present study revealed a significant difference for children in study and control groups according to their pain sensation after the implementation of the training session [ $Z=5^*$ ,  $P<0.001$ ]. Where, all children in study group (100%) experienced no pain during their needle free insulin injection compared to those children in control group who were experiencing pain with needle injection either moderate (46.7%) or severe (53.3%). The same results were found between children in study and control group regarding to their pain sensation for insulin injection in follow up [ $Z=5.002^*$ ,  $P<0.001$ ]. It was concluded from the present study that the needle free insulin injection (INJEX<sup>TM</sup> Germany) promotes no pain sensation for type 1 diabetic children. Finally, it is recommended that, encouraging the nurses to attend continuous workshop about needle free insulin injection for diabetic children. Providing enough needle free insulin injection devices (INJEX<sup>TM</sup> Germany) in pediatric hospitals.

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**Keywords:** free needle insulin injection (INJEX<sup>TM</sup>Germany), diabetic children, pain sensation, needle insulin injection

### 1. Introduction:

Type 1 diabetes mellitus, formerly known as insulin dependent diabetes, is a chronic disease characterized by hyperglycemia secondary to inadequate production of insulin by the pancreas. This occurs as a result of autoimmune destruction of the insulin producing beta cells in the islets of Langerhans<sup>(1)</sup>. The incidence of type 1 diabetes in children has been increasing by approximately 3% per year worldwide, particularly in children younger than age 5. The prevalence of type 1 diabetes mellitus in Saudi Arabian children and adolescents is 109.5 per 100,000 which is considered as high prevalence<sup>(2)</sup>.

The needle free insulin injection (INJEX<sup>TM</sup>Germany) is a spring loaded variable dose injector to which a disposable plastic ampoule attaches and containing the insulin. The activated trigger

releases the spring propelling the insulin under a high velocity through a micro orifice (0.17mm) in the ampoule tip under a pressure of ~3000 psi. The stream of insulin displays a specific cone like dispersion pattern in the subcutaneous tissue with a relatively large surface area. It seems plausible that this dispersion pattern enhances absorption of insulin into the circulation, thus explaining a more immediate glucose lowering effect<sup>(3-4)</sup>.

Needle free insulin injection (INJEX<sup>TM</sup> Germany) offers advantages over other methods of insulin administration, such as it is virtually painless, tissue preserving convenient for delivering variable doses, eliminates the risk of needle stick injuries, eliminates cross contamination, reduces disposal costs, can be used everywhere and easy to operate and long lasting<sup>(4,5)</sup>. Disadvantages of needle free insulin

injection (INJEX™Germany) include cost of the equipment and need an extensive training<sup>(5)</sup>

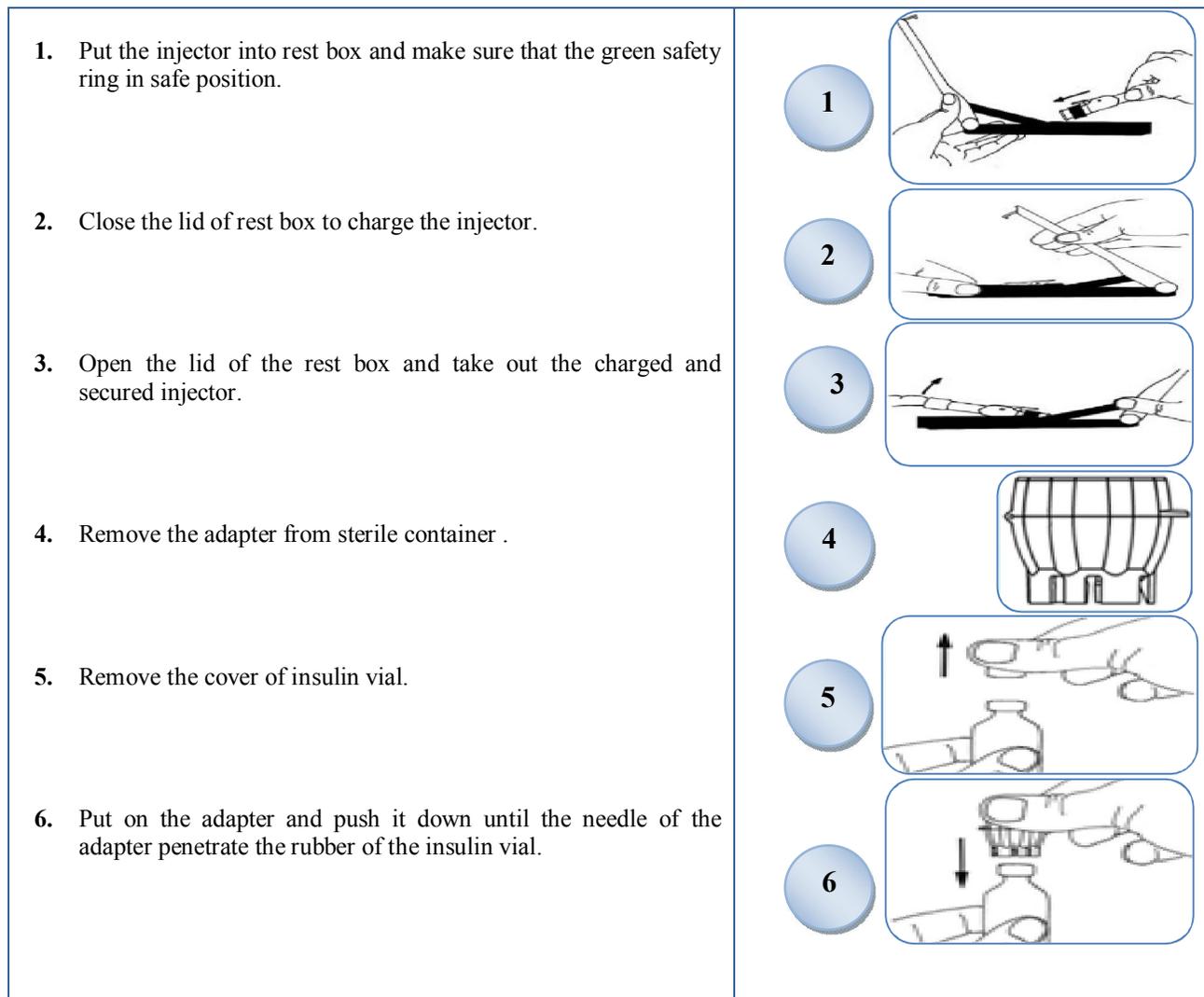
The International Association for the Study of Pain (IASP) defined pain as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage"<sup>(6)</sup>. Pain is of paramount importance to accurately assess and treat pain so as to minimize the potential detrimental adverse effects. It is difficult to treat a modality that is not clearly defined, therefore accurate assessment of pain is crucial to effective treatment<sup>(7)</sup>.

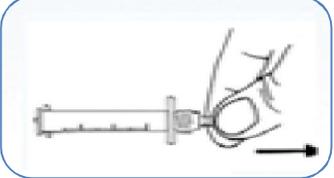
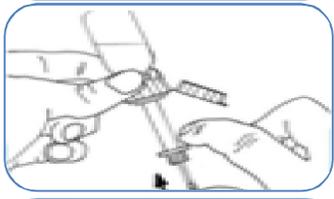
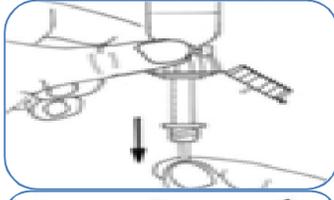
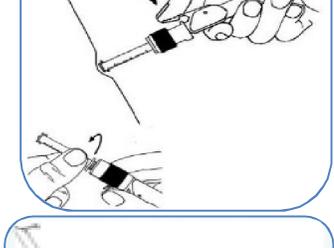
Recently, the needle free insulin injection has been shown to safely, efficaciously deliver insulin for diabetic children. It is a non invasive procedure that employ a high speed jet to puncture the skin and deliver drugs without the use of a needle, so it is minimizing the occurrence of the skin local reactions

such as Ecchymotic and Lipodystrophy lesions for children<sup>(8,4)</sup>.

Trained pediatric nurses play a critical role in empowering diabetic children to better manage diabetes through applying the most safe method in insulin delivery for these diabetic children through providing them and their families with the required information and consultations as well as advantages and disadvantages of insulin administration methods<sup>(9)</sup>. They also need to explain the characteristics of the various types of insulin, the proper mixing and dilution of insulin, and how to substitute another type when their usual brand is not available<sup>(10)</sup>.

The pediatric nurses should train the children and their parents about the appropriate technique in administering the free needle insulin injection that is clarified in figure (1)<sup>(11)</sup>.



<p>7. Remove the ampoule from sterile container and push the cartridge a little to the outside.</p>	
<p>8. Open the adapter and insert the ampoule into the vial then rotate it on clockwise until it securely fastened .</p>	
<p>9. Turn the vial upside down and push the cartridge to the end.</p>	
<p>10. Pull the cartridge slowly to the outside and withdraw the desired amount of insulin.</p>	
<p>11. Now screw the filled ampoule as far as it will go into the opened end of the injector.</p>	
<p>12. Push the green safety ring forward into the safe off position.</p>	
<p>13. Press the injector perpendicular onto the injection site at a <b>90° angle</b>, until <b>the skin is clearly dented</b> and the ampoule tip is completely enclosed by the skin.</p> <ul style="list-style-type: none"> <li>• Activate the trigger and <b>keep the Injector firmly in place for two seconds</b> after the injection.</li> <li>• Unscrew the Ampoule from the Injector.</li> </ul>	
<p>14. Put the safety green ring downward and put it on the rest box to charge it for next time.</p>	

**Figure (1):** explain the procedure steps of needle free insulin injection(INJEX™Germany) <sup>(1)</sup>.

The drawing pictures were taken from INJEX Pharma AG[internet].2012. Available from: <http://www.injex.com>. <sup>(6)</sup>.

**Aim of the study:**

To investigate the needle free versus needle insulin injection on pain sensation among type 1 diabetic children

**Hypothesis:**

Type 1 diabetic children who are using needle free insulin injection exhibit no pain than those used needle one.

**2. Materials&method:****Materials:**

**Research design:** Randomized control clinical trial design was used in this study.

**Setting:**

This study was conducted in the Pediatric Diabetes Clinic at King Fahad Hospital of University , University of Dammam in Al Khobar city.

**Subjects:**

Systematic random sampling of 30 children who have type 1 DM and their mothers were selected from the previous mentioned setting .Subjects were divided into two homogenous groups ,15 children for each group, control and study groups. Control group received the hospital routine of insulin therapy(needle insulin injection), while study group received needle free injection.

**Tool:** two tools were used in this study.

**Tool one: Faces pain scale**

It was developed by Wong & Baker,(1988)<sup>(12)</sup> to assess the pain intensity for children aged 3 to 7 years. To assess the children's pain, the child is asked to point to a face that best describes their pain intensity they are experiencing (figure2)<sup>(10)</sup>

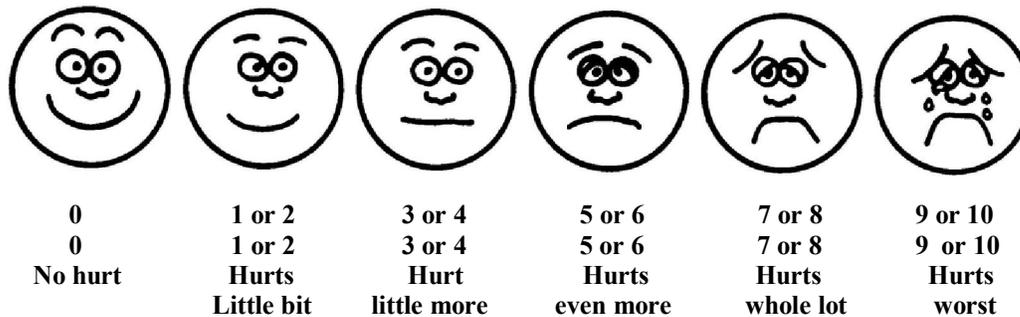


Figure 2. Faces pain scale<sup>(10)</sup>

**Tool two: Numerical rating scale**

It is a ten cm pain scale that was developed by Jensen *et al* .(1986)<sup>(13)</sup> and modified by Ferreira,*et al*.(2011)<sup>(14)</sup>, to measures the pain intensity for children aged 7 years and above. Children are asked to rate their pain from 0 to 10, choosing the number that best represents the intensity of the pain they are experiencing. [Generally, no pain=0, mild pain=1-3, moderate pain=4-6 & severe pain =7-10], figure (3)

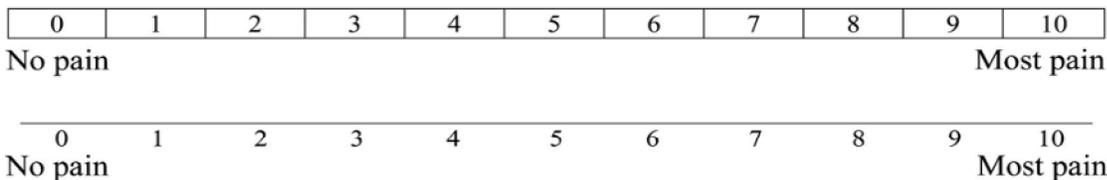


Figure 3. Numeric Pain Scale (NPS)<sup>(10)</sup>

In addition, the demographic data for children and their mothers were added, children's data such as age, gender and educational level. Mother's data such as age, educational level and occupation.

**Method:**

1. Ethical approval was asserted from local institutional committee .
2. The permission was obtained from responsible authorities in the Diabetes Clinic at King Fahad Hospital of the University of Dammam in Al- Khobar City.
3. Consent form was obtained from the parents of children who participated in the study.
4. Confidentiality and anonymity of individual response were guaranteed.
5. Tool one and two were translated to Arabic language by the researcher.

6. Tools validity has been done by five experts in pediatric field regarding to the Arabic translation (validity was 95%).
  7. Pilot study was carried out on five type 1 diabetic children to test feasibility and applicability of the tools.
  8. Assessment of demographic data for type 1 diabetic children and their mothers for both groups (control and study) were obtained by the researcher.
  9. The researcher assessed the children's pain intensity for children in both groups before and during the insulin administration therapy by using the tool one and two.
  10. One session of interview for every child and his mother in study group was carried out by the researcher to train them about the needle free insulin injection . The session was done immediately before the use of needle free insulin injection, its time ranged from 45-60 minutes.
  11. In follow up [after 3months of using needle free insulin injection],
  12. the researcher assessed the children's pain intensity before and during the insulin administration therapy by using the tools.
- Scoring system of children's compliance in follow up:  
The total items of needle free insulin procedure was 19, each one of them was divided into three categories; always(3), sometimes(2), and never done(1).So, the total score was 57.

**N.B**

- The pain sensation for all studied subjects (study and control) was assessed by the researcher through the pain scale before the insulin administration therapy for all children and it was zero grade (no pain)
- New site was selected in applying insulin administration therapy for children.

**Data Analysis**

Statistical analysis of the data was carried out by the researcher using the SPSS program for Windows, version 15.0. Data were presented using descriptive statistics in the form of percentages for qualitative variables, and median and interquartile range for quantitative variables. Qualitative variables were compared using chi-square and P-value tests, Wilcoxon test, Fisher's exact test ,Mann-Whitney test, correlation coefficient (R), values of attributed risk reduction (ARR) and values of number wanted to treat (NNT). *P*-value of <0.05 was considered statistically significant.

Value of ARR=quantities the contribution of a risk factor in producing the outcome in those exposed to the risk factor.

$$\text{Value of NNT} = \frac{1}{\text{ARR}}$$

**3. Results**

Table (1) presents the distribution of type 1 diabetic children according to their demographic data in both groups (study and control).It was shown that the age of majority of children was 10 years and more for study (53.3%) and in control (73.3%) groups. While, the age of children ranged from 5 years and less than 10 years in study (46.7%) and control (26.7%) groups. The median and interquartile range equal 11(3)and 12.3(5) for study and control group respectively.

It was observed that more than half of children in study group (53.3%) were female and 46.7% of them were male. While, 53.3% of children in control group were male and 46.7% of them were female. It was also noticed that 73.3% of children in study group had primary education and 26.7% of them had intermediate education. While, 66.7% of children in control group had intermediate education and 33.3% of them had primary education.

**Table (1):** The distribution of type 1 diabetic children according to their demographic data in both groups.(study and control)

Children's Demographic Data	Study group		Control group	
	No.15	%	No.15	%
<b>Age (years):</b>				
■ From 5-	7	46.7	4	26.7
■ ≥ 10	8	53.3	11	73.3
Min.-max	7-14		7-15	
Mean ±SD	10.5 ± 2.3		12.3 ± 2.7	
Median (IQR)	11(3)		12.3(5)	
<b>Gender:</b>				
■ Male	7	46.7	8	53.3
■ Female	8	53.3	7	46.7
<b>Level of school education:</b>				
■ Primary	11	73.3	5	33.3
■ Intermediate	4	26.7	10	66.7

Table (2) illustrates the distribution of children’s mothers according to their demographic data. It was noticed that the age of majority of mothers was more than 30 years in study (100%) and control (93.3%) groups. It was observed also that 66.7% of children’s mothers in study group had high education , 13.3% of them had intermediate and 20% of them had primary education. While 46.7% of children's mothers in control group had high education , 13.3% of them had intermediate and 40% of them had primary education. It was shown that most of children's mothers in both groups were not working [80% in study group and 86.7% in control group]. However, the working mothers were 20% in the study group and 13.3% in the control group.

Table (3) portrays the percentages distribution of type 1 diabetic children according to their pain sensation of insulin administration after insulin administration and in follow up.

A significant difference was illustrated for children in study and control groups according to their pain sensation after insulin administration [ $Z=5^*$ ,  $P<0.001$ ]. Where, all children in study group (100%) experienced no pain during their needle free insulin injection compared to those children in control group who were experiencing pain with needle injection either moderate (46.7%) or severe (53.3%). The same results were found between children in study and control group regarding to their pain sensation in follow up [ $Z=5.002^*$ ,  $P<0.001$ ]

The significant difference was found for type 1 diabetic children in both groups regarding to their local reaction of insulin injection in follow up ( $X^2=20.000^*$ ,  $P<0.001$ ). Where, all children in study group (100%) didn’t have ecchymotic lesions compared to 60% of children in control group. In addition, all children in study group (100%) didn’t

have lipodystrophy lesions compared to 80 % of children in control group as clarified in table (4).

It was noticed that the majority of children in study group were always followed the exact procedure of needle free injection in their daily insulin dose administration, except minority of them who were following it either sometimes or never (point no. 14 and 15 in children's compliance of free needle insulin administration) as clarified in the table (5).

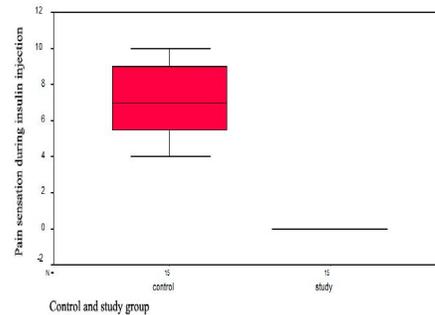


Figure (3) of box plot which clarifies the median of pain sensation immediately after insulin administration

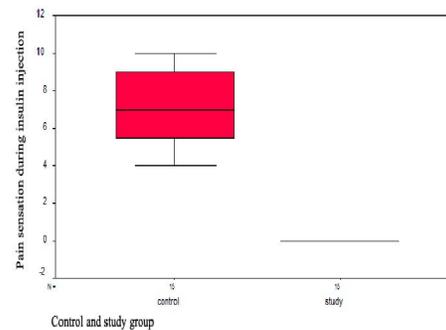


Figure (4) of box plot which clarifies the median of pain sensation in follow up (after three months)

**Table (2):** The distribution of children's mothers according to their demographic data in both groups.

Children’s mother Demographic Data	Study group		Control group		Test	
	No.15	%	No.15	%	X <sup>2</sup>	P
<b>Age (years):</b>						
■ <30	0	0.0	1	6.7	1.034	0.3
■ ≥ 30	15	100	14	93.3		
Min.-max	33-48		29-53			
Mean ±SD	38.9±4.2		41.2±7.0			
Median (IQR)	39(7)		40(13)			
<b>Educational level:</b>					1.222	0.2
■ Primary	3	20	6	40		
■ intermediate	2	13.3	2	13		
■ high	10	66.7	7	46.7		
<b>Occupation:</b>					0.120	0.6
■ Working	3	20	2	13.3		
■ Non working	12	80	13	86.7		

**Table (3):**The percentages distribution of type 1 diabetic children according to their pain sensation of insulin administration immediately after insulin administration and in follow up for both groups.

Children's Pain sensation	Immediately after insulin administration				Significant test	In follow up (after three months)				Significant test	Study Test	Control Test	
	Study		Control			Study		Control					
	No. 15	%	No. 15	%		No. 15	%	No. 15	%				
<ul style="list-style-type: none"> <li><span style="color: #008080;">■</span> No pain</li> <li><span style="color: #008080;">■</span> Mild</li> <li><span style="color: #008080;">■</span> Moderate</li> <li><span style="color: #008080;">■</span> Severe</li> </ul>	15	100	0	0.0	Z=5* P<0.001	15	100	0	0.0	ARR=100 % NNT=1  Z=5.002* P<0.001	0	Z#=1.34 2 P=0.2	
Min.-max			53.										
Mean ±SD			3										
Median (IQR)			4-10										
	0		7.13±2.10			0			6.93±2.2				
			7(5)					7(5)					

N.B: Pain sensation before insulin administration for both groups (0) will be mention in methodology as a data base.  
 Z Mann Whitney Test Z# Wilcoxon Test P Probability of chance (significance)

**Table (4):** The distribution of type 1 diabetic children's local reaction of insulin injection in follow up among both groups

Children's local reaction of insulin injection	Follow up (after three months)				Test
	Study		Control		
	No.15	%	No.15	%	
Ecchymotic lesions					FET P=0.02
<span style="color: #008080;">■</span> Yes	0	0.0	6	40	
<span style="color: #008080;">■</span> No	15	100	9	60	
Lipodystrophy lesions					X <sup>2</sup> =20.000* P<0.001
<span style="color: #008080;">■</span> Yes	0	0.0	12	80	
<span style="color: #008080;">■</span> No	15	100	3	20	

**Table (5):** The percentages the distribution of children's compliance for needle free insulin injection Administration in follow up (after three months) among study group.

Items	Never done		Sometimes		Always		Total	
	No.15	%	No.15	%	No.15	%	No.15	%
1. Putting the injector into rest box and make sure that the green safety ring in safe position.	0	0.0	0	0.0	15	100	15	100
2. Closing the lid of rest box to charge the injector.								
3. Opening the lid of the rest box and take out the charged and secured injector.	0	0.0	0	0.0	15	100	15	100
4. Removing the adapter from sterile container .	0	0.0	0	0.0	15	100	15	100
5. Removing the cover of insulin vial.								
6. Putting on the adapter and push it down until the needle of the adapter penetrate the rubber of the insulin vial.	0	0.0	0	0.0	15	100	15	100
7. Removing the ampoule from sterile container and push the cartridge a little to the outside.	0	0.0	0	0.0	15	100	15	100
8. Opening the adapter and insert the ampoule into the vial then rotate it on clockwise until it securely fastened.	0	0.0	1	6.7	14	93.3	15	100
9. Turning the vial upside down and push the cartridge to the end.								
10. Pulling the cartridge slowly to the outside and withdraw the desired amount of insulin.	0	0.0	0	0.0	15	100	15	100
11. Screwing the filled ampoule as far as it will go into the opened end of the injector.	0	0.0	0	0.0	15	100	15	100
	0	0.0	0	0.0	15	100	15	100
	0	0.0	0	0.0	15	100	15	100
	0	0.0	0	0.0	15	100	15	100
Items	Never done		Sometimes		Always		Total	
12. Pushing the green safety ring forward into the safe off position.	0	0.0	0	0.0	15	100	15	100
13. Cleaning the skin over the insertion site with antiseptic swab.								
14. Pressing the injector perpendicular onto the injection site at a 90° angle, until the skin is clearly dented and the ampoule tip is completely enclosed by the skin.	1	6.7	3	20	11	73	15	100
15. Activating the trigger and keep the injector firmly in place for two seconds after the injection.	2	13.3	4	26.7	9	60	15	100
16. Unscrewing the Ampoule from the Injector.	2	13.3	4	26.7	9	60	15	100
17. Putting the safety green ring downward , close the rest box and put the injector and the rest box in the bag.								
18. Changing the site of injections.	0	0.0	0	0.0	15	100	15	100

19. Applying alcohol swab after the inject of insulin.	0	0.0	0	0.0	15	100	15	100
	0	0.0	1	6.7	14	93.3	15	100
	0	0.0	1	6.7	14	93.3	15	100

#### 4. Discussion

Needle free injections (INJEX™ Germany) employ a high speed jet to puncture the skin and deliver drugs without the use of a needle. They have been used to deliver a number of macromolecules including vaccines and insulin, as well as small molecules, such as anesthetics and antibiotics<sup>(8)</sup>.

The present study revealed that needle free insulin injection is minimizing or preventing the pain sensation for diabetic children. However, the significant difference was shown in the study and control groups according to their pain sensation after and in follow up of needle free insulin administration ( $Z=5^*$ ,  $P<0.001$ ) (Table 3). This was confirmed by many authors who stated that the level of pain is predominantly perceived lower by using needle free insulin injection caused less skin irritation and bruising. It is also provide an attractive alternative to the pen injection for most patients and it is an effective in delivering insulin<sup>(8,15-16)</sup>.

In addition, the needle free insulin injection prevents pain sensation that is derived from the local reactions of skin irritation such as lipodystrophy and ecchymotic lesions. As needles will hit a blood vessel on injection, producing local bleeding or ecchymotic lesions and changing the needle length or other injecting parameters does not appear to alter the frequency of bleeding or bruising. It is stated also that both pen and syringe devices have been associated with lipohypertrophy as well as insulin pump cannulae<sup>(17)</sup>. However, injecting in lipohypertrophic areas affects the rate of absorption of the insulin, contributing to poor blood glucose control<sup>(18)</sup>. While, patients who suffer from lipodystrophy may observe reduced lesions incidence and severity following a using of needle free injection<sup>(4)</sup>. The results of the current study were parallel with such findings, in which the significant difference was found for children in both groups regarding to their local reaction of insulin injection in follow up of health education program ( $X^2=20.000^*$ ,  $P<0.001$ ) as clarified in table(4). As, all children in study group who use needle free insulin injection didn't have any ecchymotic or lipodystrophy lesion.

Furthermore, the needle free insulin injection (INJEX™ Germany) is approved by the values of attributable risk reduction (ARR) which clarified its attribution 100% of experience no pain sensation among type 1 diabetic children in follow up. Plus, the value of number needed to treat (NNT) emphasized

such findings, where one out of one child will experience no pain.

On contrary, Houtzagers et al, (1988)<sup>(19)</sup> mentioned that there is a significant local reaction in using needle free injection including bleeding ,hematomas and pain. Worth et al,(1980)<sup>(20)</sup> reported also that the needle free injection was offset by more bleeding.

The present study found also that most of type 1 diabetic children and their mothers in study group were compliant with their regimen of needle free insulin injection in follow up. Where, the majority of them were always applying procedure points in their daily insulin dose administration, except minority of them who were following it either sometimes or never (26.7%,13.3% respectively) as clarified in the table (5). The children's compliance for needle free insulin injection in this study could be related to certain factors; needle free insulin injection is a non invasive procedure, where the permits of subcutaneous insulin delivery without a needle lead children experience no pain or discomfort as illustrated in table (5).

Educational level of children could be a reason for enhancing the children's understanding of their training sessions as all children in study group joined either primary or intermediate schools (Table 1). This was supported by Stephen, (1991)<sup>(21)</sup> who cited that schooling fosters the development of cognitive processes in children. Mother's work could be other factor, however, it was found that 80% of mothers in this study were housewives that enable them to spend more time to care for their children as portrayed in table (2).

#### Conclusion

It was concluded for the present study that the needle free insulin injection (INJEX™ Germany) promotes no pain sensation for type 1 diabetic children. Where, the significant differences were shown in study and control groups according to their pain sensation after insulin administration and in follow up [ $Z=5^*$ ,  $P<0.001$ ].

#### Recommendation

1. Encourage nurses for attending health education program about needle free insulin injection for diabetic children.
2. Develop a manual about needle free insulin injection procedure.

3. Continuous workshop for nurses regarding evidence with respect to needle free insulin injection that include theoretical and practical aspect.
4. Availability of needle free insulin injection devices (INJEX™ Germany) at hospitals.
5. Further study related needle free insulin injection must be conducted on a large subjects size of type 1 diabetic children.

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