Ability to handle, and patient preference for, insulin delivery devices in visually impaired patients with type 2 diabetes

Charles Fox*, Carol McKinnon, Anthony Wall, Simon A Lawton

ABSTRACT

In this comparative study, 86 patients with type 2 diabetes and visual impairment were evaluated on their preference for, and ability to operate, three different insulin delivery systems – InnoLet® (NovoNordisk), Humulin® NPH Pen (Eli Lilly) and vial and syringe (Becton Dickinson). Patients found the clocklike dose scale on InnoLet® significantly easier to read than that of the other systems (92% were able to read four doses, versus 45% and 61% with Humulin® Pen and syringe respectively, both $p < 0.001$), and showed greater ability to set and dispense a 20 unit dose without instruction. After reading the packaging information leaflet and brief verbal instruction, 99% of patients were able to correctly set and dispense three consecutive insulin doses with InnoLet® compared with 85% with Humulin® Pen and 64% with syringe ($p = 0.001$ and $p < 0.001$, respectively). Ability to set and deliver insulin was not however clearly related to visual acuity. On questionnaire, 87% of patients expressed an overall preference for InnoLet®, and 13% for Humulin® Pen ($p < 0.001$); no patients preferred the syringe. In conclusion, insulin delivery systems designed to simplify accurate, reliable insulin delivery for people with visual impairment can improve the ability of such patients to repeatedly set and deliver the correct insulin dose.

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KEY WORDS

type 2 diabetes; insulin delivery system; visual impairment

Introduction

Type 2 diabetes is a progressive disorder, associated with a steady decline in beta-cell function, from a mean 51% at diagnosis, to 28% after 6 years[1]. This reduction in glucose-lowering capacity necessitates introduction of insulin in the majority of patients, within 15 years of diagnosis[2]. By lowering HbA_{1c} through the use of intensive therapy, morbidity associated with microvascular, and probably macrovascular, complications can be significantly reduced[3,4]. Any reduction in HbA_{1c}, however small, contributes to improving prognosis[3]. Nonetheless, many eligible patients are denied the benefits of timely insulin therapy due to misconceptions about appropriate use of insulin in type 2 diabetes, and anxiety concerning the practical and organisational skills required to follow complex dosing regimens. From the patients' perspective the anticipated pain and social stigma of injections compound the delay in receiving optimal glucose-lowering therapy[5].

Current insulin delivery systems vary in format and ease of use. Insulin is available in vials, to be drawn up using a conventional syringe, but this method provides poor dose accuracy[6]. Patients who experience particular difficulty in accurate self-dosing include the elderly, as well as younger people with poor vision or impaired manual dexterity. Visual impairment is common in diabetes, with acuity 6/12 or worse in 16% of people over the age of 65, rising to nearly 27% by age 75[7]. Thus, insulin delivery systems that are easy to use by people with poor vision are essential for effective diabetes management, and to allow patients to maintain their independence. Prefilled insulin cartridges, inserted into disposable or durable insulin delivery devices with short needles, can improve dose accuracy and increase compliance rates compared with more traditional methods, and quality of life is often enhanced through their use[8–11]. Since patients with type 2 diabetes perform significantly worse than age-matched controls on tests of learning and reasoning[12], this patient group – of whom over 50% will require daily insulin therapy at some stage[13] – may derive particular benefit from delivery systems that are easy to handle and simple to operate. It is anticipated that rational insulin delivery systems that make maximum use of existing sensory capacity will be preferred by patients, and will help those with sensory impairment capitalise on their remaining abilities.

Materials and methods

In this multicentre, open, randomised, comparative study, 86 insulin-naive patients with type 2 diabetes were drawn from three centres in the UK. During a handling test, patients tested three insulin delivery systems – InnoLet® (*Novo Nordisk,* Denmark), Humulin® NPH Pen (*Eli Lilly*, USA), and vial and 0.5 ml syringe (*Becton Dickinson*, USA). NovoFine® 30G 8 mm needles (*Novo Nordisk*) were used with the prefilled pen

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devices; the syringe had a pre-attached Micro-Fine + 8 mm needle. The study was conducted in accordance with good clinical practice.

Patients

Patients were included if they were ≥55 years with diet- and/or oral-hypoglycaemic-agent-treated type 2 diabetes. Since one of the study objectives was to assess the ease with which patients could learn how to operate the respective delivery systems, people with a history of insulin self-administration were excluded to avoid potential bias from previous exposure to the systems tested. Visual acuity (corrected near vision) in the best eye was between 0.5 (20/40) and 0.1 (20/200) as assessed with a Rosenbaum card.

Assessment methods

Accuracy when viewing dose scale

Ability to administer insulin safely and independently relies on repeated accurate dose reading. Patients were therefore asked to read four randomly selected whole-numeral dose settings on each insulin delivery system under standardised direct illumination.

Handling test

The handling test comprised three parts.

Part I: intuitive test

Patients were asked to set and discharge a 20 unit insulin dose with a minimum of standardised instruction and no specific training, using each of the three delivery systems. The time allowed to complete the task was 2 min. Patients were assessed as successful in completing this section if the dose was set within 5% of that requested and the full dose dispensed. In this, and all other parts of the study, doses were delivered into a disposable container.

Part II: written instruction

Patients were provided with those sections of the manufacturers' package information leaflets giving details on how to operate the device. After a maximum of 3 min reading time, participants set and dispensed three doses of insulin. Doses were randomly selected (dose range 4–50 units, with one dose > 30 units) but consistent between devices and patients (dose 1 = 23 units, dose 2 = 42 units, dose 3 = 17 units), and dose setting was deemed accurate if it fell within 1 unit for doses < 20 units and within 5% for doses > 20 units. Successful completion of this section required all three doses to be correctly set and delivered.

Part III: verbal instruction and demonstration

Patients only entered this section of the trial if they were unable to complete the previous section successfully. Verbal instruction and a demonstration on how to operate the system correctly were provided, and a 5 min limit was set. The patients were then requested to set and dispense three further randomly selected doses (dose 1 = 40 units, dose 2 = 29 units, dose 3 = 19 units). Successful completion of this section was assessed on the same criteria as in part II.

Questionnaire

On finishing the handling test, participants completed a questionnaire on their preference for certain features of each delivery system. Only the question on overall preference required both qualitative and quantitative answers.

Data analysis

Setting sample size to a minimum of 80 patients ensured that group differences would be detected with a power of 85% at a 0.05 level of significance (a = 5%). The global difference between delivery systems was calculated with Fisher's exact test using SAS© proc freq. If global difference was significant ($p \leq 0.05$), all three pairwise comparisons between devices were made using Fisher's exact test. In the case of pairwise comparisons a Bonferroni correction to the value was applied. Because InnoLet® was tested twice, the threshold value was lowered from 5% to 2.5%.

Results

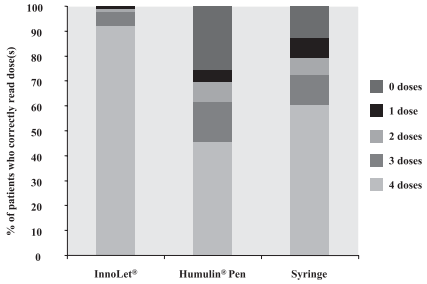
Study population characteristics

The study population comprised 86 patients (51 male, 35 female), mean age 69 years and mean disease duration 6 years. Visual acuity ranged between 0.29 and 0.5 in 46 patients (54.1%), 0.2 and 0.29 in 17 patients (20%) and 0.1 and 0.2 in 22 (25.9%) patients. Only five (5.8%) reported a subjective hand disability.

Withdrawal and non-completion of handling test

No patients withdrew prematurely from the trial, and only two subjects (2.3%) were unable to complete the handling test. In both cases this was due to inability to handle the vial and syringe.

Figure 1. More patients were able to read four consecutive doses settings with InnoLet® than with Humulin® Pen or syringe



Visual accuracy when reading dose scale

The majority of patients could read all four doses correctly with InnoLet® (79 patients, 92%), compared with 39 (45%) with Humulin® Pen, and 52 (61%) with the syringe (Figure 1). The differences between InnoLet® and both the other devices were highly statistically significant ($p < 0.001$ for both). The number of patients in each visual acuity group who were able to read all four doses correctly decreased with decreasing acuity for all devices, but the decline was less apparent with InnoLet® than with Humulin® Pen or syringe.

Handling test

Intuitive test

Eighty-three patients (97%) set the 20 unit dose correctly (i.e. not evaluating ability to dispense the dose) with InnoLet®, compared with 41 (48%) and 33 (39%) with Humulin® Pen and syringe, respectively. Following this, 72 patients (84%) also succeeded in dispensing the complete 20 unit dose with InnoLet®, compared with 35 (41%) with Humulin® Pen and 27 (31%) with the syringe ($p < 0.001$ between InnoLet® and both Humulin® Pen and syringe for setting and dispensing; Table 1). Mean time taken to set and dispense the correct dose was significantly shorter with InnoLet® (26 s) than with Humulin® Pen (65 s, $p < 0.001$ versus InnoLet®) or syringe (53 s, $p < 0.001$ versus InnoLet®; Figure 2). There was no clear relationship between visual acuity and ability to set and dispense the correct dose.

Written instruction

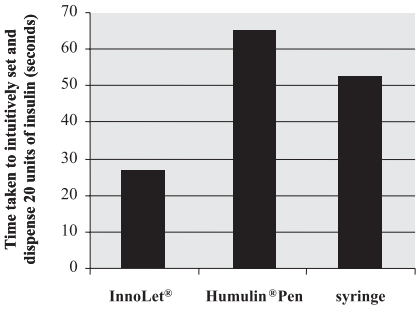
After receiving written guidance, 83 patients (97%) correctly set all three insulin doses using InnoLet®, while 69 (80%) set and dispensed all doses accurately (Table 1). This compared with 56 (65%) and 24 (28%)

Table 1. InnoLet® is the most reliable device for accurate dose-setting and insulin delivery

	InnoLet®	Humulin® Pen	Syringe
% of patients able to intuitively set and dispense 20 U insulin dose	84[a,b]	41	31
% of patients able to set and dispense three insulin doses after written instruction	80[a,c]	61	27
% of patients able to set and dispense three insulin doses after both written instruction and brief verbal instruction/demonstration	99[a,b]	85	64

[a] $p < 0.001$ versus syringe.
[b] $p \leq 0.001$ versus Humulin® Pen.
[c] $p < 0.01$ versus Humulin® Pen.

Figure 2. Patients were intuitively able to set and dispense insulin significantly more quickly using InnoLet® than Humulin® Pen or syringe



who set the dose correctly using Humulin® Pen and syringe respectively, and 52 (61%) and 23 (27%) who dispensed insulin accurately. Significantly more patients were successful operating InnoLet® compared with the other two delivery systems (dose-setting, $p < 0.001$ versus both other systems; dose-setting plus delivery, $p = 0.007$ versus Humulin® Pen, $p < 0.001$ versus syringe). Only when using the syringe did decreasing visual acuity impair patients' ability to set and fully dispense the correct dose.

Verbal instruction and demonstration

Patients who entered part III of the trial were those unable to successfully complete part II. InnoLet® accounted for 17 patients, Humulin® Pen for 34 and syringe for 62. After verbal instruction and demonstration, 17 (100%) correctly set all doses with InnoLet®, compared with 23 (68%) and 31 (50%) with Humulin® Pen and syringe, respectively ($p = 0.009$ for the difference with Humulin® Pen; $p < 0.001$ for syringe). Following this, 94% ($n = 16$) of patients correctly dispensed all three insulin doses with InnoLet®, compared with 62% ($n = 21$) and 50% ($n = 31$) with Humulin® Pen and syringe, respectively ($p = 0.019$ between InnoLet® and Humulin® Pen, and $p < 0.001$ between InnoLet® and syringe; Table 1). The proportion of subjects who set and fully dispensed all three doses correctly showed no clear relationship with visual acuity.

Following written or verbal instruction and demonstration, insulin was accurately set and dispensed by 85 (99%) patients using InnoLet®, compared with 73 (85%) and 54 (64%) with Humulin® Pen and syringe, respectively ($p = 0.001$ between InnoLet® and Humulin® Pen, $p < 0.001$ between InnoLet® and syringe). Again, there was no clear relationship between visual acuity and ability to use the devices correctly.

Questionnaire

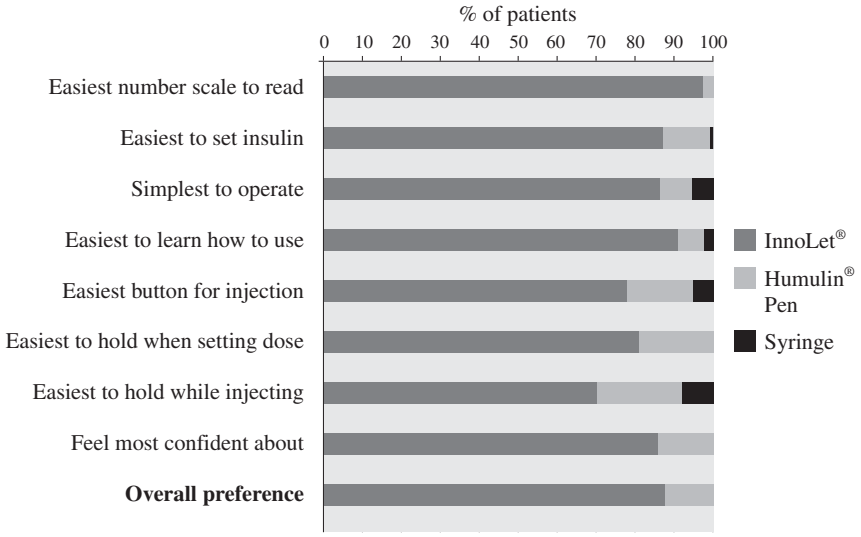
InnoLet® was the preferred delivery system of 75 (87%) patients, compared with 11 patients (13%) who chose Humulin® Pen ($p < 0.001$); no patients preferred the syringe. All the specific device features assessed were rated as significantly superior for InnoLet® ($p < 0.001$ where applicable; Figure 3). All five patients with subjective hand impairment found that the button on InnoLet® was the easiest to depress during injection. Four patients found InnoLet® the easiest to hold while setting a dose, while one preferred Humulin® Pen in this respect. Two found InnoLet® the easiest to hold while injecting, whereas two preferred Humulin® Pen. Formal statistical testing of these differences was omitted because of the small sample size.

Discussion

The need to self-inject can be a barrier to starting insulin therapy at any age. Many people with type 2 diabetes are introduced to insulin self-injection during their more advanced years, when confidence in learning new skills is declining and both physical and psychological limitations add to the burden of performing complex tasks. If patients believe that assistance from caregivers will be necessary, reluctance to be dependent may be an additional barrier to starting therapy[5].

Visual impairment – most commonly due to cataract – affects 16% of people with type 2 diabetes over the age of 65, and

Figure 3. Patients preferred InnoLet® to Humulin® Pen or syringe



Key points

- Visual impairment is common in people with type 2 diabetes.
- Accurate, reliable insulin delivery is facilitated by devices that are tailored to physical and psychological ability.
- With only minimal instruction – of a duration reasonable within a busy clinic – the majority of patients, including those with severe visual impairment, were able to demonstrate the ability to repeatedly set and dispense insulin accurately using InnoLet®.
- In comparison with Humulin® Pen and syringe, patients could accurately set and dispense insulin more reliably with InnoLet®.
- Patients became competent in using InnoLet® more rapidly, preferred the design features of InnoLet® and felt more confident about using it.

this figure rises to 27% at age 75[7]. Repeated setting and delivery of the correct insulin dose poses a challenge. Furthermore, over 50% of people with type 2 diabetes have limited joint mobility in the hands[14], and 25% have symptomatic peripheral neuropathy[15]. Arthritis and tremor increase with advancing age[16], adding to the difficulty in manually operating handheld devices. In order for patients to be willing to self-inject insulin regularly, both regimen and device should be tailored to physical and psychological ability.

In this study of 86 patients with type 2 diabetes and visual impairment, patients were able to read the InnoLet® dosing scale more reliably than that of the other systems. Although accuracy fell with reduced visual acuity, this was least pronounced with InnoLet®, and over 80% of patients with severe visual impairment (<0.2 to ≥0.1) were still able to read the dose scale, compared with less than 20% with Humulin® Pen and 41% with syringe. At every level of instruction, a greater number of patients were able to accurately set and dispense insulin using InnoLet®. In the absence of specific training, 84% set and administered the dose reliably, compared with 41% and 32% with Humulin® Pen and syringe, respectively. With only minimal training, in the form of written instruction or a 5 min explanation, 99% became proficient. Overall, 87% of patients preferred InnoLet® to Humulin® Pen or the syringe. Ratings for specific design features were significantly higher for InnoLet® across all eight categories assessed.

Since people with type 2 diabetes are significantly more likely to have difficulty performing tasks that require recall of learned skills[12,17,18], one could speculate that the patient preference for InnoLet® demonstrated in this study rests on design features that address the specific patient needs associated with type 2 diabetes. The large clock-like dial, which is set like a familiar kitchen-timer, and large-scale numbers assist accurate dose selection; audible clicks accompany delivery of each insulin unit dialled, reassuring patients about dose selection. This may account for the greater number of patients in the handling study being able to repeatedly set and dispense insulin with InnoLet® (99%) than were able to read the dose scale without error (92%). Although the preference of the five patients with subjective hand impairment in this study tended towards InnoLet®, there were too few patients to provide conclusive results. However, it seems logical that the comfortable handling of the device and large dose-delivery buttons would simplify insulin delivery for patients with weak hands.

In conclusion, the rational design of InnoLet® renders it a device suitable for accurate, reliable delivery of insulin, even in patients with visual impairment. Given a choice, the majority of patients favour InnoLet® over currently available alternatives.

Conflict of interest: This research project was funded by NovoNordisk and Charles Fox received an honorarium for taking part in the launch of the InnoLet® injection device. However, he has no ongoing commercial interest in this product.

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