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Using telemedicine and wearable technology to establish a virtual clinic for people with Parkinson's disease

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ABSTRACT

Background To develop an effective, patient-centred and sustainable service, we set up a virtual clinic (VC) for patients with Parkinson's disease, combining phone consultations and reports from wearable technology. The Parkinson's Kinetigraph (PKG) is a wrist-worn device providing objective motor assessment, generating a report used by clinicians to optimise medication regimens.

Interventions A pilot study of VC was designed using quality improvement methodology. For a VC appointment, patients were phoned by a clinician. After discussing symptoms and reviewing the PKG report, the clinician could decide on any medication changes or other interventions and relay this to the patient's general practitioner in a clinic letter. Patient feedback was gathered via questionnaires and data collected on the outcomes and timings of the consultations.

Results Over 12 clinics, 61 patients had VC appointments. Of questionnaire respondents, 89% were satisfied with VC (n=41). At VC, the clinician was able to make a treatment decision comparable to a face-to-face clinic in 79% of cases (n=48). Reasons appointments were deemed unsuccessful included issues with the PKG, speech or hearing problems and complex phase of disease. VC appointments, including administration time, last on average 22 min. This compares to 20 min face-to-face appointments but these do not include administration time.

Conclusions We have demonstrated a safe and effective VC template. Most VC appointments are equivalent to face-to-face clinic in terms of treatment outcome. Success could be further improved by appropriate patient selection. Using VC is time saving and can result in releasing face-to-face appointment slots for those in urgent need or newly referred patients. Further cost analysis is required; the cost of the PKG alone is more expensive than a face-to-face appointment, but this does not take into account other value added, such as patient convenience and satisfaction, and reduced need for ambulance transport.

PROBLEM

Parkinson's disease (PD) is a common neurodegenerative condition, its incidence increasing with advancing age. Our geriatrician-led movement disorder service operates within a large National Health Service (NHS) health board in Wales and currently cares for over 1500 people with PD and related disorders. Following National Institute for Health and Care Excellence guidance, we endeavour to offer follow-up appointments every 6 months, but this may not be sustainable in light of our increasing cohort.[1] We present a pilot study in which we have used an innovative approach combining telemedicine and wearable technology to establish a virtual clinic (VC). Our motivations are the need for a more effective service to meet increasing demand, as well as providing quality care delivered to patients in their own homes. Our aims were to design a new VC and use Plan, Do, Study, Act (PDSA) cycles for dynamic quality improvement (QI) to refine the design. We prioritised ensuring the safety of VC. We aimed to collect data on outcome, process and balancing measures to help reflect on the success of the VC pilot.

BACKGROUND

PD is a neurogenerative disorder which can cause motor symptoms consisting of bradykinesia, rigidity, tremor and postural instability. While research is ongoing, there is currently no cure or disease-modifying treatment available for PD. The strategy for management involves regular clinical review for assessment of symptoms and the optimisation of medications. Levodopa remains the gold standard tablet treatment for motor symptoms while other classes of drugs frequently used include Monoamine oxidase type B (MAO-B) inhibitors, dopamine agonists and catechol-O-methyltransferase (COMT) inhibitors. Clinical judgement is required in titrating a medication regime to the patient's needs, improving movements and mobility while minimising potential side effects (of which dyskinesia and impulse control disorder are significant examples).[2] This can be challenging, requiring expert experience and basing decisions on a point in time examination of a patient's motor signs.

The Parkinson's Kinetigraph (PKG) system, developed by Global Kinetics Corporation (GKC), is an innovative technology that facilitates this clinical decision-making. The system

involves an accelerometer device, worn like a smart watch on the wrist. It collects data on parameters including bradykinesia, dyskinesia and tremor for the 7–10 days' duration of the period worn. It also gives medication dose time reminders. After using the watch data logger for the assessment period, the patient posts in back to GKC. Algorithms are used to compare the patient's data to healthy control generating a PKG report. The report includes numerical scores, such as bradykinesia score (BKS), for which a score above a defined range suggests high levels of bradykinesia. Graphs show the data in more detail, for example, BKS on the Y axis against time of day on the X axis, with vertical lines to show medication dose acknowledgements. This allows informed and appropriate titration of medication.[3] Using the PKG system has been shown to improve motor assessment and to be useful to establishing levodopa responsiveness.[4 5] There is further evidence to endorse a treat-to-target approach, for example, up-titrating medication to get a BKS below 23.[6] Our movement disorder team has over 18 months' experience using the PKG in our clinics and 273 of our patients have had at least one reported.

Telemedicine has been practised around the world with examples in the literature dating back to the 1970s. More recent models include VCs in a range of fields, from psychiatry to orthopaedic surgery in response to pandemic COVID-19.[7 8] In the UK, some NHS directorates have VCs, notable examples include video consultation in stroke and heart failure and phone clinics for inflammatory bowel disease.[9–11] While the NHS has published its 'Long Term Plan' on putting focus on digital transformation, it has been found that the fragmentation of NHS services is proving a barrier to change.[12]

We have combined a phone clinic approach with the aid of the PKG as a surrogate for the clinical examination part of the clinical consultation. To our knowledge, this is the first pilot of a VC for patients with PD in the NHS.

MEASUREMENT

We planned to collect data that could offer a measure of the effectiveness of VC. We opted to make our primary outcome measure patient satisfaction. These data were collected by sending anonymous feedback questionnaires by post soon after the VC consultation to all patients who consented to participate. The questionnaire included a tick box agreement scale for satisfaction with VC overall, as well as specifics including their concerns being addressed and feeling listened to. It also consisted of a free text section where comments were encouraged (online supplemental appendix 1). A stamped addressed envelope was provided for the questionnaire to be returned to our office.

With regard to processing measures, we defined a successful consultation as one in which in the clinician's opinion a clinical decision could be made as if it were a face-to-face appointment, and that face-to-face follow-up could be postponed by at least 2 months. The clinical decision could include a medication change, a referral to another team (physiotherapy, for example) or the decision that the patient is stable and no action is required. Data gathered on timing and cost were compared with regular clinics as a balancing measure.

DESIGN

In the initial planning phase, the project was discussed with the clinical service leads and clinical director for approval. We confirmed the project is a service evaluation and thus not require ethical approval. VC would not replace face-to-face clinics completely; we planned to review patients via VC then face-to-face clinic on an alternating six monthly basis.

A geriatric medicine registrar was appointed to oversee the project and to lead the clinics. Team meetings were held to iron out the logistical challenges off setting up the VC. In terms of secretarial support, the current PD secretary took on the administration role, in exchange for some other duties being reallocated to other colleagues. A suitable room within the outpatient department was selected for running the clinic, and plans were made to order a mobile phone and laptop with trust information technology (IT) access.

A focus group was held to ascertain our patients' thoughts on the project. We offered patients who were in the clinic, waiting for their routine follow-up appointment, the chance to take part in a focus group. Seven agreed to take part and of those six made positive comments and said they would be interested in the VC. They highlighted that the term 'virtual clinic' was misleading, with connotations of a virtual reality headset which is not the case. It may also be misinterpreted as videoconferencing. Thus, we decided to use the term 'phone clinic' when referring it to patients and on the patient information leaflet. We have continued to call it a VC for the purposes of this write-up, as this is the name given to most clinics of a similar format and makes our report easily searchable.

Figure 1 shows the process mapping for the VC. To select a cohort of patients, the database of those who had had recent PKGs was reviewed to identify those who were due a follow-up appointment in the coming 1 or 2 months. Their VC appointment was booked prior to when their face-to-face one was due, so if the VC was unsuccessful, they would have prompt face-to-face follow-up within 1–8 weeks as already planned. This ensured the pilot was safe and would not compromise patient care if things did not go as planned. If the phone clinic addressed their needs, the upcoming face-to-face appointment could be cancelled and the time reallocated to new patient slots in the clinic.

STRATEGY

PDSA cycle 1

During the pilot, the same doctor consulted for all the VCs. The doctor had been trained in PKG interpretation and was also familiar with using the PKG in face-to-face

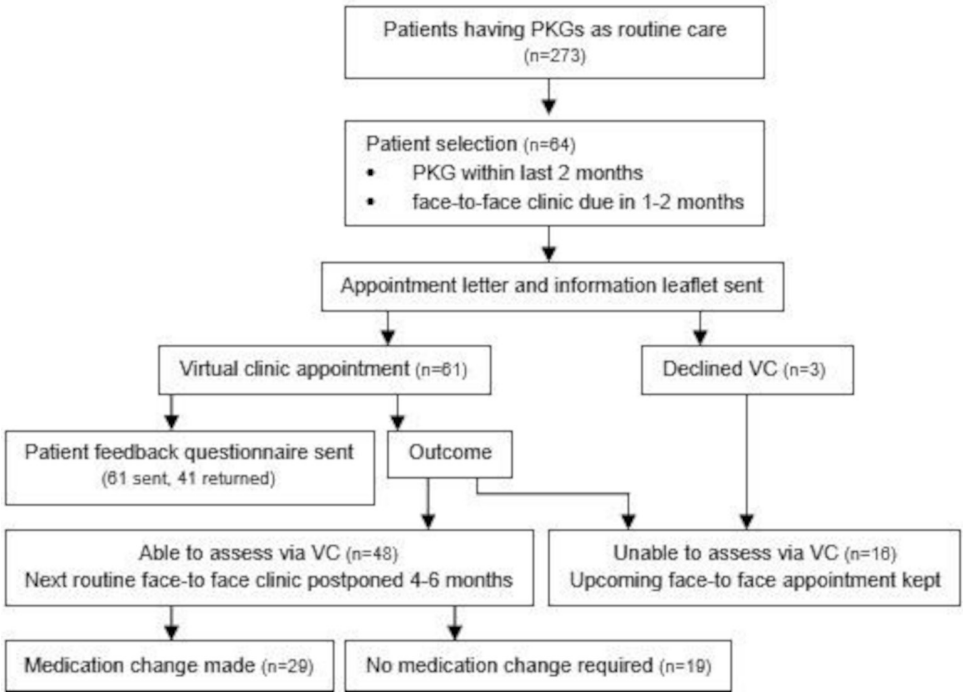

Figure 1 Flow chart of clinic process. PKG, Parkinson's Kinetigraph; VC, virtual clinic.

clinics. Appointment letters were sent out 2 weeks in advance of the pilot VC in September 2018. These had an attached patient information sheet explaining the new clinic. The first clinic comprised five follow-up appointments. Each patient was phoned at home at their allotted appointment time, their symptoms discussed and PKG reports reviewed. The encounter was recorded on the proforma for the clinical record and for data collection. Each planned phone contact was made successfully. The PKG report was accessible in four out of the five cases, a fault having been reported on the other. Medication changes were made in one consultation and one referral to day hospital was made. The average consultation length was 16 min, which was longer than anticipated but reflected the clinician adapting to a new consultation type.

PDSA cycle 2

After the first two clinics were run from an office, as the planned clinic room was not ready, it became evident that as long as there was a working phone and health board computer, the clinic could be run from different sites. To allow flexibility, avoiding allocating a fixed clinic room, we were able to rotate the site of the clinic to offices or outpatient departments which were not otherwise in use at the time. Due to the amount of time spent on the phone in that session, we decided that a landline is preferable to a mobile phone due to user comfort. As the consulting clinician became more familiar with the phone consultation, the average consultation length did decrease to 15 min over the next two clinics (a total of 13 consultations). There were no further PKG faults at this point, suggesting if they remain uncommon it would not be time efficient to check all PKGs prior to sending a clinic appointment; however, this was reviewed after further cycles.

PDSA cycle 3

Using the pro-forma over the first three clinics highlighted some omissions that could aid data collection if amended. This included time of appointment start and end, and if a relative was also on the line (as this had been the case in several appointments). An updated proforma was introduced for the subsequent clinics. Patient feedback questionnaires had been created in the initial planning phase and patients had been consented to this being posted to them during their phone consultation. However, a logistical issue of purchasing stamps for the project meant that these had not been sent out at this point, when we had planned for them to be sent immediately after the VC. This was addressed and the questionnaires went out approximately 6 weeks after the first consultation, but more promptly from this point on.

After the five clinics (totalling 22 consultations) the mean consultation length remained at 15 min. There were no further PKG problems and all but three consultations were felt successful; that a clinical decision could be made as if it were a face-to-face consultation.

PDSA cycle 4

While we had measured the consultation time, we had underestimated the amount of secretarial time required for typing and sending the extra dictated clinic letters. There also seemed to be unnecessary duplication, as during the consultation the clinic doctor would type a few notes directly into the online clinical neurology notes. It was decided to trial the doctor typing the clinic letter directly into the online portal after the consultation, where it could be promptly sent to the general practitioner (GP) by the secretary. A template for the clinic

Table 1 Patient demographics

n	61
Mean age (years)	70.1
Age range (years)	50–86
Male/female (n)	44/17
Mean BKS	33.7
Mean levodopa equivalent dose (mg)	463.98

BKS, bradykinesia score.

letter was created with layout and headings to speed up the typing of the letter.

Feedback questionnaires from the first three clinics become available. The free text feedback was reviewed in an attempt to address any actionable points, but the patient's concerns surrounded the inability of phone consultation to replace the face-to-face consultation completely, which was never our intention.

PDSA cycle 5

As the appointments remained lengthy, the focus of the consultation was changed to mainly reporting back PKG results and discussing motor symptoms, in an attempt to fit in more follow-up appointments in the VC session. At the eighth clinic, eight patients were booked in, compared with the previous maximum of six as it was felt that the concept had been sufficiently practised. This clinic ran to time but did require extra administration time at the end for typing the clinic letters. We ran a total of 12 clinics to collect sufficient data, then paused for data, feedback and cost efficiency analysis.

RESULTS

Over the course of 12 clinics, 61 patients had VC appointments. Three patients declined a VC appointment. Patient demographics are shown in table 1.

Our primary outcome measure was patient satisfaction, measured by questionnaire. Of the 61 sent, we received 46 returned patient feedback questionnaires. Of those respondents, 89% agreed or strongly agreed they we satisfied with VC (n=41). A histogram of responses is shown in figure 2. Twenty-one of the respondents gave feedback in the free text section. Of those, five were very positive, praising the convenience. Six were neutral, and showed a trend for finding the concept acceptable but would have a preference for a face-to-face appointment. The 10 negative comments included difficulties using the phone with speech problems and tremor, not knowing the VC doctor and not fully involving the spouse or carer. Comments are summarised in online supplemental appendix 2.

In order to address our processing measure, we devised a definition of a successful consultation. A consultation was deemed successful if the clinician felt that the outcome of the consultation was likely to have been the

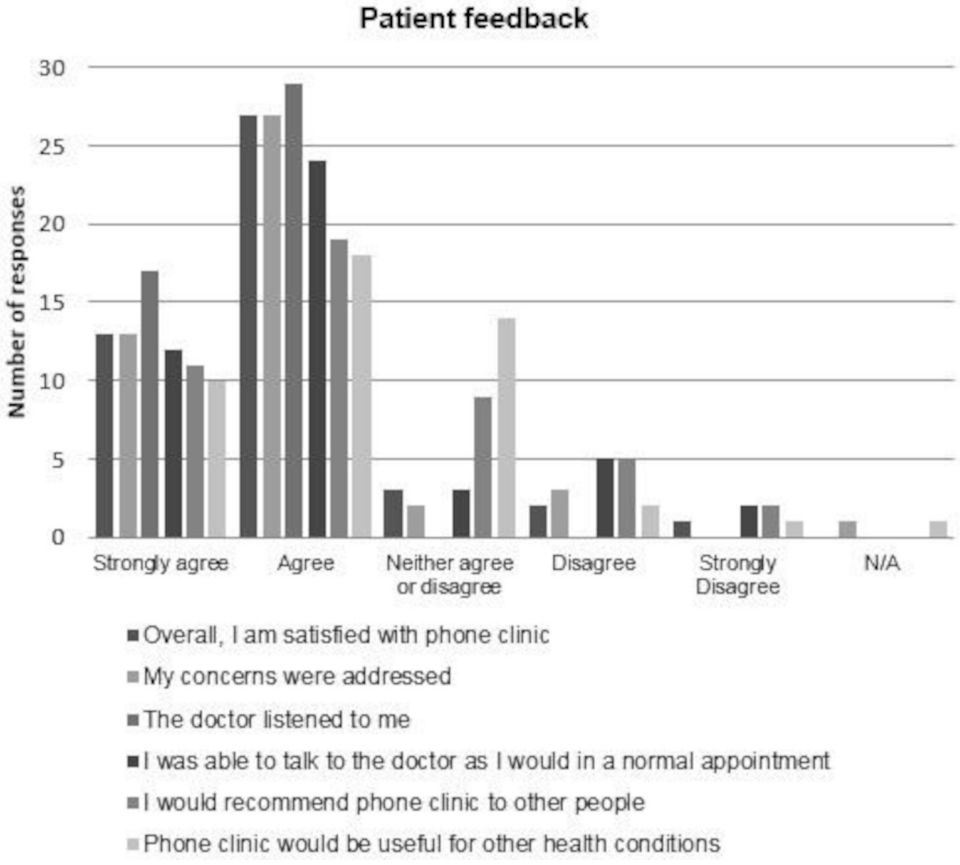

Figure 2 Histogram of patient satisfaction questionnaire results. N/A, not applicable.

same as a face-to-face clinic. This could include a decision to change medications, a referral to another multidisciplinary team member or a decision to follow-up only. If the face-to-face clinic appointment was required within 8 weeks after the VC, it was considered unsuccessful. By this definition, 79% of appointments (n=48) were successful. Reasons that the consultation was unsuccessful included complex phase of disease (n=5), problems with the PKG (n=5), needing a blood pressure (BP) reading (n=2) and speech problems (n=1).

Those problems with the PKG include a device fault in two cases, two reports not available and one discrepancy between history and PKG.

For balancing measures, we examined consultation length and clinic costs. Our current face-to-face clinic template varies week on week and has a combination of 40 min new patient and 20 min follow-up slots split between two consultants, one or two junior doctors and two PD specialist nurses over 3.5 hours. In terms of the VC timings, in the most recent three clinics the average phone consultation length was 12 min, but given the administration time required for PKG to be reviewed and interpreted prior to the call, the pro-forma filled in and letter typed, eight follow-up slots were the most we were able to fit in the 3-hour clinic slot for one doctor. This suggests an average administration time of 10 min per patient. This total clinic time of 22 min compares to a regular follow-up slot of 20 min, but this regular slot does not include the dictation and typing of the clinic letter which is done in another session. Colleague consensus is that the face-to-face appointments often run late, longer than 20 min slot allocated and the extra administration time can vary from 30 min to 2 hours. Of the 61 consultations, 35 of the previously planned face-to-face contacts could be postponed a median time of 6 months, which could equate to seventeen 40 min new patient clinic slots. Statistical variation charts are available in online supplemental appendix 3.

With regard to expense, the VC design reduces some costs by eliminating the need for clinic premises, support staff and ambulance transport as well as reducing secretarial input. It also adds value in terms of convenience, environmental benefits and in terms of infection control. In the pilot phase, an additional training grade doctor was assigned, so VC was in addition to face-to-face clinic. A face-to-face follow-up appointment in movement disorder clinic costs £116 which includes the premises, support staff and clinician time (but not ambulance transport as this comes from a different budget). Currently, the cost of each PKG is £225. This package includes the postage of the data logger to the patient, postage back to GKC and the PKG report made available via the online portal. Even without accounting for the cost of a clinician's session, this makes VC using PKG appear more expensive than a normal clinic. However, this does not take into account the value-added features mentioned above, reduced use of ambulance transport and new patient slots created to reduce waiting lists.

LESSONS

Given the innovative nature of this clinic type, the process involved developing and trialling novel ideas and our findings may help those interested in setting up similar clinics. Patient selection is vital in the success of VC. As this was a pilot project, patients were selected for clinic based on having recent PKGs. This had an impact on the number of unsuccessful appointments. In reality, having a referral system with suitability criteria would mean that the movement disorder clinic doctor meeting the patient face to face (and likely having known them for some years) could offer phone clinic follow-up to those deemed appropriate; without speech or hearing problems and with non-complex phase of disease. This would undoubtedly improve the likelihood of a meaningful VC follow-up consultation.

After these 12 clinics, our clinic template consisted of up to eight slots 20 min apart, with 20 min of administration time at the end of the session. This allowed for interpreting the PKG prior the phone call, the consultation and then typing the GP letter. This meant that the majority of phone calls were at the expected appointment time. Our initial template involved shorter administration time for the clinic doctor as letters were dictated then typed by a secretary. We found this inefficient overall as the doctor was writing onto a paper pro-forma, typing into the online portal as well as making a dictation which would require typing. We used our online portal entry as a focused GP letter to avoid unnecessary duplication.

We found using a pro-forma useful for guiding the phone consultation initially, but in our opinion the whole process becomes more natural and similar to a face-to-face consultation with experience of phone consultations. In two cases, the patients disclosed that they found it easier to talk about hypersexuality (in the context of impulse control disorder) on the phone as they had been embarrassed to mention it in face-to-face clinic.

One useful lesson was the ease of providing the clinic in terms of location and equipment. Any clinic room with access to a hospital computer and phone line was suitable for clinic and this could be changed or adapt based on the rooms in use on that day. No clinic nurses are required. Our secretary would print a clinic list with patients' phone numbers and collate the paper notes; however, these may not always be necessary depending on different health board IT systems.

Five consultations were unsuccessful due to faults with the PKG. We reflected on the need to check the PKG prior to booking the clinic appointment early on in PDSA cycle 1, but had thought this would be too time consuming to be beneficial. However, given the total number of PKG problems over the pilot, we would recommend that a clinic administrator be asked to check the PKG has been done prior to booking the appointment. Further unsuccessful consultations could be avoided by asking patients to take their own BP readings on a home monitor.

In this pilot, the 61 VC consultations freed up 35 face-to-face follow-up slots. If we were to run a weekly VC following

our eight-patient template (and assuming in at least 57% the face to face could be postponed), we can extrapolate this could create more than 118 new patient slots in 1 year.

LIMITATIONS

Our major limitation is while this was a pilot study using QI methodology, it was not controlled or randomised. We have shown this kind of VC is feasible and safe; however, further research is required to fully assess the impact of VCs on patient care. It is difficult to define the success of a consultation. We opted for the definition that the clinician felt the outcome of the consultation was likely the same as it would have been if it were a face-to-face clinic. This is useful for a broad overview but is subjective and unblinded.

In our pilot project, the VC consultations were carried out by one senior registrar in geriatric medicine specialty training with prior experience in movement disorders and under the supervision of consultant geriatricians. Patients would not have met the registrar in the clinic before, whereas they may know the rest of the geriatrician-led movement disorder team well and VC with their regular clinician may have been more useful. Also, the registrar may not have been able to make decisions on the most complex patients whereas an experienced consultant with prior knowledge of that patient may have been able to do so.

The cost analysis is limited as it does not take into account the doctor's session cost or ambulance transport costs. There is a suggestion that VC is more costly to run than face-to-face clinics, due to the PKG alone costing more than a regular clinic. However, we have discussed other ways in which the VC can add value. With ever advancing health technologies and competitive pricing, there may be more cost-effective options in the future. The current PKG model involves paying per report, and it is not possible to invest in buying the PKG loggers up front.

CONCLUSIONS

In conclusion, we have piloted a safe and effective VC using PKGs and illustrated the steps involved in a set-up. During our PDSA cycles we reduced consultation times and reflected on patient selection for VC as a key for success.

Most patients found VC acceptable. The majority of the checkbox feedback was very positive. A small proportion of returned questionnaires included free text feedback. We received positive feedback as well as neutral and critical comments suggesting that 'phone clinic better than no follow up at all'. The mean age of our cohort was 70, supporting that age is not a barrier to using technology such as the PKG and trying new ideas like VC.

Our findings suggest that using VC with PKG is felt to be equivalent to a face-to-face clinic in terms of the ability of the clinician to make a decision on treatment. When taking into account administration time, VC is more time efficient and can be used to increase the availability of face-to-face slots for those in need or for new patients (thus reducing waiting lists). A more detailed cost analysis is needed but it appears in the short term, VC with PKG may be more expensive.

The PKG is just one of now several movement sensor systems in PD. Health technology is ever evolving and new systems and devices are frequently becoming available. We have shown an example of using a technology to help develop a service, and we can expect to see more similar opportunities in other areas of medicine in years to come. We hope that this pilot project may inspire others to consider their own VC, learning from our shortcomings and building on our success.

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