Institution: Bournemouth University

Unit of Assessment: 3

Title of case study: Creating a global market for a novel medical device – how BU research helped make it happen

Period when the underpinning research was undertaken: 2015 – 2020

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Professor Robert Middleton	Head of the Orthopaedic Research Institute	2015 - current (visiting Professor 2009 - 2015)
Associate Professor Tom Wainwright	Deputy Head of the Orthopaedic Institute	2015 - current (visiting Fellow 2009 - 2015)
Louise Burgess	Research Associate	2017 - current
Shayan Bahadori	Lab Technician	2016 - current
Dr James Gavin	Senior Lecturer in Exercise Physiology	2014 - 2019
Tikki Immins	Research Development Manager	2014 - current

Period when the claimed impact occurred: 2015 – 31 December 2020

Is this case study continued from a case study submitted in 2014? No

1. Summary of the impact (indicative maximum 100 words)

Venous thromboembolism (or Deep Vein Thrombosis (DVT)) is the leading cause of preventable deaths in hospital. Research by Professor Robert Middleton and Associate Professor Tom Wainwright has informed the development of Firstkind Ltd.'s geko™ medical device and was critical in obtaining National Institute for Health and Care Excellence (NICE) and Food and Drug Administration (FDA) approval for the device in the UK and USA respectively.

Their research not only demonstrated its use to prevent DVTs, but led to the optimisation of the device settings, and expanded its clinical indications for use, to include the reduction of oedema (swelling). This fundamental role in the development of the geko™ has led to 700,000 unit sales in 14 countries and adoption in the National Health Service (NHS) during the COVID-19 pandemic.

2. Underpinning research (indicative maximum 500 words)

The geko™ [*Figure 1*] and the technology behind it, is the only product of Firstkind Ltd. It is a battery-powered, disposable, neuromuscular electro-stimulation device designed to increase blood flow in the veins of the leg. Middleton and Wainwright's research into its effects, leading to regulatory approval, has been primarily funded as part of a GBP1,200,000 grant made to Firstkind Ltd. from the Medical Research Council and Technology Strategy Board.

Figure 1

Firstkind Ltd. approached Middleton and Wainwright to design and conduct the first ever study of the geko™ in patients following surgery [R1]. Middleton and Wainwright are internationally recognised for developing enhanced recovery after surgery pathways for total hip replacements, which aim to accelerate post-operative recovery. Reducing avoidable post-operative complications, and allowing early physiotherapy are essential, and so the study evaluated the effectiveness of the geko™ in preventing DVTs and the formation of lower limb oedema.

The randomised control trial (RCT) compared the geko™ T1 device with the use of compression stockings in order to prevent DVT and oedema following hip replacement surgery [R1]. Results showed that not only was the device safe, tolerable for patients, and effective in preventing DVT, but that it significantly reduced oedema [*Figure 2*].

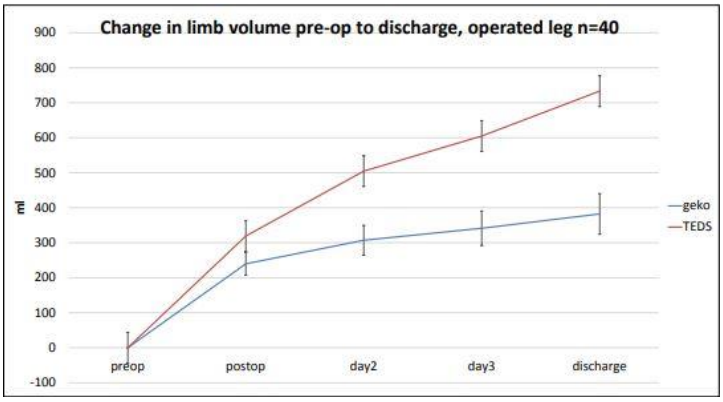

Figure 2

Before the RCT [R1], the device settings had been informed by research on healthy subjects in a seated position (knee flexed). Middleton and Wainwright's research discovered that the device settings did not always work optimally for patients with oedema or neuropathy, or for patients in bed whose knee was extended. Further research [R2] confirmed this and highlighted the opportunity to optimise the device further.

The TURBO clinical study (ClinicalTrials.gov Identifier: NCT02316210. Unpublished due to commercially sensitive data) was therefore undertaken, which studied patients who had not responded to the geko™ T1 device. Firstkind Ltd. used data from this study to increase the stimulation range of the geko™ devices so that it worked effectively in all patients.
The TEDs2 study [R3] replicated the methodology of the TEDs1 study with additional blood flow measurements and used the next generation of geko™ devices. It demonstrated that the updated geko™ T2 and R2 devices increased blood flow, were effective in preventing DVT, and significantly reduced oedema, as well as continuing to be safe and tolerable for patients.

Further to their surgical studies, Middleton and Wainwright conducted a pilot RCT on patients with ankle sprains, which demonstrated that the device reduced swelling after ankle sprain [R4]. The study was the first clinical trial to demonstrate the geko™ could be independently applied by

patients at home, and worn for at least 8 hours a day, for 7 consecutive days, with no adverse effects.

Wainwright led further research which has clarified the link between the action of the geko™; an increase in blood flow, and reduced oedema by examining the effects of the device on microcirculatory blood flow in the thigh [R5]. The research showed the geko™ increased microcirculatory blood flow by 400% [R5]. The study required the team to invent a novel measurement technique to counter for artefact movement whilst using a Laser Speckle Contrast Imaging system (LSCI) [R6]. This technique has since been used by Firstkind Ltd. in other research looking at the application of the device to heal chronic wounds.

3. References to the research (indicative maximum of six references)

R1-R6 have been rigorously peer-reviewed and published in internationally-recognised journals.

R1 Wainwright, T.W., Burgess, L.C. and Middleton, R.G. (2018). A feasibility randomised controlled trial to evaluate the effectiveness of a novel neuromuscular electro-stimulation device in preventing the formation of oedema following total hip replacement surgery. *Heylion.* 4(7). 10.1016/j.heliyon.2018.e00697

R2 Gavin, J. P., Cooper, M., and Wainwright, T. W. (2018). The effects of knee joint angle on neuromuscular activity during electrostimulation in healthy older adults. *Journal of Rehabilitation and Assistive Technologies Engineering*. 5(1). https://doi.org/10.1177/2055668318779506

R3 Wainwright, T.W., Burgess, L.C., Middleton, R.G. (2020). A single centre feasibility randomised controlled trial comparing the incidence of asymptomatic and symptomatic deep vein thrombosis between a neuromuscular electrostimulation device and Thromboembolism Deterrent Stockings in post-operative patients recovering from elective Total Hip Replacement. *Surg Technol Int*. 28(36), pp.289-298. PMID: 32250444

R4 Wainwright, T.W., Burgess, L.C., Middleton, R.G. (2019) Does Neuromuscular Electrical Stimulation Improve Recovery Following Acute Ankle Sprain? A Pilot Randomised Controlled Trial. *Clin Med Insights Arthritis Musculoskelet Disord*.12. https://doi.org/10.1177/1179544119849024

R5 Bahadori, S., Immins, T. and Wainwright, T.W. (2017). The effect of calf neuromuscular electrical stimulation and intermittent pneumatic compression on thigh microcirculation. *Microvascular Research*. 111, pp.37-41. 10.1016/j.mvr.2017.01.001

R6 Bahadori, S., Immins, T. and Wainwright, T.W. (2017) A Novel Approach to Overcome Movement Artifact When Using a Laser Speckle Contrast Imaging System for Alternating Speeds of Blood Microcirculation. *Journal of Visualised Experiments*.126. 10.3791/56415

4. Details of the impact (indicative maximum 750 words)

NICE & FDA approval

Research by Middleton and Wainwright demonstrated that the geko™ device not only increases blood flow and prevents DVTs, but also reduces oedema. This research led to Firstkind Ltd. receiving FDA approval for the geko™, firstly for venous thrombosis [E1a] and then later for oedema [E1b], which means it can be used as a medical device in the USA.

The 510(k) FDA summary refers specifically to data from the initial TEDs 1 trial [R1] [E1a,b] as the reason for the approval for both applications. In the venous thrombosis 501(k) summary there is also mention of the improvements made to the original T-1 device, which has “been redesigned for more efficient current delivery”. The TURBO study informed this redesign.

The geko™ also received NICE approval, meaning it is approved for medical use in the UK. The approval specifically refers to data from the TEDs1 trial [R1] and TEDs2 trial [R3] [E2a,b]. In the NICE guidelines for the device, data from 2005 demonstrated that the 25,000 patients in hospital with DVT and associated VTE that year cost the NHS GBP640,000,000. The cost-saving per patient using the device, for those patients with an unmet need for mechanical prophylaxis, is GBP197 per patient, representing a significant saving to the NHS, particularly at a time when older populations are expected to increase [E2a,b].

As noted by Firstkind Ltd., the research was pivotal in achieving both NICE and FDA approval: "Data arising from this research was used together with other data in support of an application to NICE and a submission to the FDA for clearance for the use of the device following total hip replacement surgery. Both submissions were successful and of course critical for business success… interim analysis from [the TEDS2 study [R3]] was again used for a successful FDA submission, this time for the treatment of oedema." [E3a]

Benefits to Firstkind Ltd

The NHS and FDA approvals have expanded potential markets for the device, opening up markets on every continent. Firstkind Ltd. refer to the TURBO study as being used "to produce the next generation of the device, which provided a greater reach and usability of the geko™ device in clinical practice." [E3a] Firstkind Ltd. reference BU's research extensively in their brochures, which shows that the research is a crucial part of their day-to-day marketing which drives sales and commercial expansion into new markets. Firstkind Ltd. states that: "The studies completed at Bournemouth have provided critical feedback and guidance on matters of product optimisation especially in respect to clinician/nurse training, patient wear, product fitting and technology reach. This real-world patient-facing interaction, feedback and advice has rightly challenged our prior strategy and led to corrective action." [E3b] Over 700,000 individual units have been sold to date in at least 14 countries, and Firstkind Ltd. won the International Life Sciences award for the Most Innovative MedTech Company 2020 [E4].

Use in clinical practice

BU's research and innovation collaboration for the geko™ device has provided direct impact to improving care for patients. Before BU's involvement, the device was designed for use with athletes and healthy individuals to aid recovery from sport or to prevent DVTs whilst flying. Wainwright and Middleton's research led to the device being available to help patients in a wide range of clinical settings, especially for those for whom traditional approaches, such as TEDS and intermittent pneumatic compression, are unsuitable.

As an example, the geko™ is used in 28 NHS Trusts, "who are working to adopt the device into their acute stroke pathways for patients at high risk of blood clots." [E5] The Stroke Association states that there are over 100,000 strokes per year in the UK at a cost to society of GBP26,000,000, so medical devices that can prevent blood clots could make a significant difference to NHS services [E6].

The device has also been used to combat potential side-effects of COVID-19, with over 4,700 devices ordered by the NHS [E7] to help prevent VTE, which research has shown to be a potential high-risk side effect of the disease.

Benefits to patients

A study measured VTE events at 90 days post-stroke. Data showed that of the patients treated with Intermittent Pneumatic Compression (IPC) alone, 2.4% suffered a VTE event within 90 days, compared to a 0% in patients prescribed the geko™ device alone. Patients prescribed the device also showed no adverse events and reported a greater tolerance of the geko™ device compared to IPC [E8]. A patient prescribed the device described it as "absolutely brilliant" compared to TEDS and IPC [E9].

In Canada, the device has been rolled out for chronic wound patients, leading to some patients experiencing complete healing where other treatments had been unsuccessful [E10].

5. Sources to corroborate the impact (indicative maximum of 10 references)

E1a Department of Health and Human Services (2015) *Geko™ T-2 Neuromuscular Stimulator*. Amherst, MA: Food and Drug Administration. [online]. Available at: https://www.accessdata.fda.gov/cdrh_docs/pdf18/K180082.pdf [Accessed 14 June 2016].
E1b Department of Health & Human Services (2018) *Geko™ T-2 And Geko™ Plus R-2 Neuromuscular Stimulators.* Amherst, MA: U.S. Food & Drug Administration. [online]. Available at: https://www.accessdata.fda.gov/cdrh_docs/pdf18/K180082.pdf [Accessed 09 February 2018].

E2a NICE (2014) *3 Clinical Evidence | The Geko Device For Reducing The Risk Of Venous Thromboembolism | Guidance* | p8 #3.9 & #3.15 [online] Available at: https://www.nice.org.uk/guidance/mtg19/chapter/3-Clinical-evidence 3.9 [Accessed 4 November 2018].
E2b National Institute for Health and Care Excellence (2016) *Review Of MTG19: The Geko Device For Reducing The Risk Of Venous Thromboembolism*. [online] Centre for Health Technology Evaluation, pp.4,7. Available at: https://www.nice.org.uk/guidance/mtg19 [Accessed 20 March 2020].

E3a Firstkind Ltd. (2018) *Testimonial letter*
E3b Firstkind Ltd. (2020) *Testimonial letter*

E4 Ghp-news.com (2020) *International Life Sciences Awards 2020*. [online] Available at: https://www.ghp-news.com/issues/intl-life-sciences-awards-2020/14/#zoom=z [Accessed 8 December 2020].

E5 Med-Tech Innovation (2019) *Wearable developed to combat blood clot risk* [online] Available at: https://www.med-technews.com/news/wearable-developed-to-combat-blood-clot-risk/ [Accessed 14 May 2020].

E6 Stroke Association (2018) *State Of The Nation: Stroke Statistics*. [online] p.4. Available at: https://www.stroke.org.uk/sites/default/files/state_of_the_nation_2018.pdf [Accessed 16 November 2020].

E7 Hospital Times (2020) *NHS orders new device to stem blood clot risk in Covid patients* [online] Available at: https://www.hospitaltimes.co.uk/nhs-orders-new-device-to-stem-blood-clot-risk-in-Covid-patients/ [Accessed 20 October 2020].

E8 Hospital Times *(*2020) *Covid-19: an endothelial disease?* [online] Available at: https://www.hospitaltimes.co.uk/Covid-19-an-endothelial-disease/ [Accessed 16 November 2020].

E9 Firstkind. n.d. *The Geko™ Device Trial At The BMI Harbour Hospital - Firstkind*. [online] Available at: https://www.gekodevices.com/geko-videos/bmi-harbour-hospital/ [Accessed 19 May 2020].

E10 Firstkind (2015) *Community Care Geko™ Device Roll-Out In Canada - Firstkind*. [online] Available at: https://www.gekodevices.com/news-events/community-care-geko-device-roll-out-in-canada/ [Accessed 20 October 2020].