Relative cost-effectiveness of three compression bandages in treating newly diagnosed venous leg ulcers in the UK

Objective: To assess the clinical outcomes and cost-effectiveness of using a two-layer cohesive compression bandage (TLCCB; Coban 2, 3M, US) compared with a two-layer compression system (TLCS; KTwo, Urgo, France) and a cohesive inelastic bandage system (CIBR; Actico, L&R, Germany) in treating newly diagnosed venous leg ulcers (VLUs) in clinical practice, from the perspective of the UK's National Health Service (NHS).

Method: This was a modelling study based on a retrospective cohort analysis of the case records of patients with a newly diagnosed VLU randomly extracted from the The Health Improvement Network (THIN) database who were treated with TLCCB, TLCS or CIBR. No significant differences were detected between the groups. Nevertheless, analysis of covariance was performed to enable differences in patients' outcomes between the groups to be adjusted for any heterogeneity in baseline covariates. Clinical outcomes and cost-effectiveness of the alternative compression systems were estimated over 12 months after starting treatment.

Results: There were 250 patients in each group. Time from wound onset to starting compression was a mean of two months. The healing distribution of the TLCCB-treated patients was significantly different from that of the other two cohorts (p=0.003); the probability of healing at 12 months was 0.62, 0.51 and 0.49 in the TLCCB, TLCS and CIBR groups, respectively. Patients treated with TLCCB experienced better health-related quality of life (HRQoL) over 12 months (0.86 quality-adjusted life years (QALYs) per patient), compared with those treated with TLCS and CIBR (0.83 and 0.82 QALYs per patient, respectively). The 12-month NHS wound management cost was £3693, £4451 and £4399 per patient in the TLCCB, TLCS and CIBR groups, respectively.

Conclusion: Within the model's limitations, treating newly diagnosed VLUs with TLCCB instead of the other two compression systems appears to afford a more cost-effective use of NHS-funded resources in clinical practice, since it is expected to result in increased healing, better HRQoL and a lower wound management cost for the NHS.

Declaration of interest: This study was commissioned by 3M Healthcare, UK. The study sponsors had no involvement in the study design, analysis and interpretation of the data, and the writing of this manuscript. The views expressed in this article are those of the authors and not necessarily those of the sponsors. The authors have no other conflicts of interest to declare.

Actico • Coban 2 • compression • compression bandage • cost-effectiveness • KTwo • UK • venous leg ulcer • wound • wound care • wound dressing • wound healing

Venous leg ulcers (VLUs) are a major cause of morbidity and decreased health-related quality of life (HRQoL).[1] The prevalence of VLUs in adults >18 years of age in the UK has been estimated at one per 100 individuals in 2017/18.[2]

Venous disease is the result of ongoing pooling and congestion of venous blood. This congestion in deep veins increases ambulatory pressures and results in venous hypertension, which subsequently increases the hydrostatic pressure in the superficial veins. This alteration in pressure dynamics leads to capillary fluid loss and soft tissue oedema. Venous pressure in a standing individual is largely hydrostatic,[3] hence, the external pressure necessary to counteract this effect progressively reduces up the leg, as the hydrostatic head is effectively reduced.[3] Consequently, external compression is usually applied to a VLU in a graduated fashion, with the highest pressure at the ankle and decreasing gradually toward the knee.[3,4] The application of graduated external compression has been shown to minimise or reverse the vascular changes that occur in a VLU, by forcing fluid from the interstitial spaces back into the vascular and lymphatic compartments.[3,4]

Up to 49% of newly presenting VLUs can be induced to heal by applying adequate levels of sustained, graduated compression.[5] Once healed, some VLUs recur and patients can experience a repeated cycle of ulceration, healing and recurrence. Some VLUs fail to heal in a timely manner and they then become hard-to-heal.[6]

Compression bandages are the mainstay of treatment for VLUs. Several different types of compression bandaging systems are available, each of which may have advantages over the others for particular applications. Moreover, they vary greatly in their ability to provide sustained compression, owing to differences in their structure and content of elastomeric yarns.[4] Other factors, such as limb circumference and shape, also affect

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the pressure produced beneath a compression bandage.[7] However, there is some anecdotal evidence that nurses in the community have difficulty determining which type of compression bandage to apply.

A systematic review of different compression bandages for VLUs concluded that the rate of ulcer healing was increased with use of compression bandages compared with no compression.[4] It also found multicomponent compression systems to be more effective than single-component systems, and those with elastic bandages were more effective than inelastic systems. However, there were no clear differences in the effectiveness of the different types of high compression.[4]

The use of any one particular compression system will depend on several parameters including: choice; a patient's adherence; acceptability and ease of application of the system used; and also the cost of each system. Furthermore, research has shown that the probability of patients achieving full wound closure is related to their adherence with compression therapy which in turn is related to the ease and comfort while wearing the compression bandage.[8,9] A randomised controlled trial found that the VLU healing rate was similar between patients wearing a two-layer system and those wearing a four-layer system.[10] However, patients had a stronger preference for the two-layer system. Notwithstanding, it is unknown whether different two-layer systems generate similar outcomes and costs in clinical practice. Hence, the aim of the present study was to compare the clinical outcomes and costs of using a two-layer cohesive compression bandage (TLCCB; Coban 2, 3M, US) with a two-layer compression system (TLCS; KTwo, Urgo, France) and a cohesive inelastic bandage system (CIBR; Actico, L&R, Germany) to treat newly diagnosed VLUs in clinical practice, from the perspective of the UK's National Health Service (NHS).

Methods

Study design

This was a modelling study based on a retrospective cohort analysis of the case records of patients with a newly diagnosed VLU randomly extracted from The Health Improvement Network (THIN) database.

Health economic modelling

A Markov model was constructed in Excel (Microsoft Corp., US) depicting the management of newly diagnosed VLUs (Fig 1). The model considered the costs and consequences of the decision by a clinician to initially manage a VLU with TLCCB, TLCS or CIBR. The time horizon of the model was 12 months.

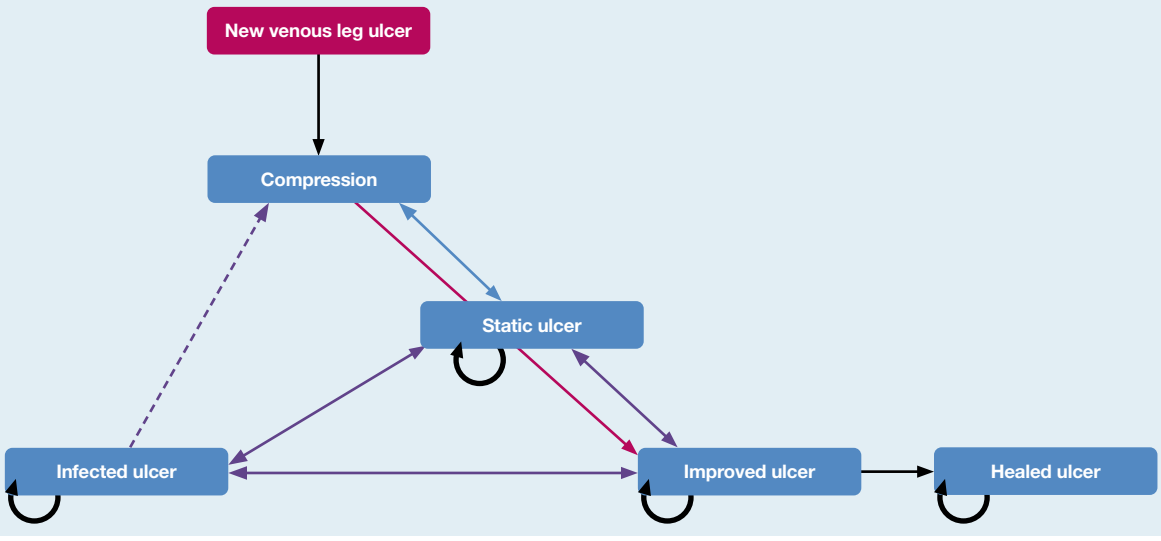
VLUs entered the model and were initially managed with TLCCB, TLCS or CIBR. They then transitioned to one of two health states (i.e., static ulcer (an ulcer that remains unchanged) or improved ulcer (followed by healed ulcer)). The ulcers either remained in their current health state or moved to one of the other states and transitioned monthly for a total of 12 months. The model's health states were mutually exclusive and so each VLU represented in the model could be in only one health state at any given time during the time horizon of the model.

The model was populated with a combination of transition probabilities, clinical outcomes and healthcare resource utilisation estimates pertaining to the cohort of patients extracted from the THIN database.

THIN database

The THIN database contains electronic records of >11 million anonymised patients entered by general practitioners (GPs) from >560 practices across the UK. The patient composition within the THIN database has been shown to be representative of the UK population, in terms of demographics and disease

Fig 1. Markov model



distribution,[11] and theoretically contains patients' entire medical history.

In particular, the database collects data on the dates that patients registered or left their practice as well as demographic data. All medical conditions and symptoms recorded electronically during a patient's consultation in the general practice are recorded in the THIN database, thereby building up long computerised medical histories using Read Codes.[12] GP prescribing is computerised and entered directly into the database. Prescriptions not issued electronically (e.g., during home visits) are also entered; however, there is a possibility of under-recording of such items. Information is also recorded on referrals to secondary care, including the specialty. Secondary care and other medically related information received by the practice is entered into the database. This includes details on hospital admissions, discharge medication, diagnosis, outpatient consultations, investigations and treatment outcomes. Details on a range of variables such as body mass index and smoking are also recorded.

(THIN is a registered trademark of Cegedim SA in the UK and other countries. IQVIA Medical Research Data (IMRD) incorporates data from THIN, a Cegedim Database. Reference made to THIN is intended to be descriptive of the data asset licensed by IQVIA.)

Ethical approval

Ethical approval to use patients' records from the THIN database for this study was obtained from the Research Ethics Committee that appraises studies using the THIN database (Reference number: 22SRC015).

Study population

A sample of >2400 patients who fulfilled the following criteria was extracted from the THIN database:

- Were ≥18 years of age
- Had a Read code for a VLU between 1 October 2016 and 31 December 2019
- Received TLCCB, TLCS or CIBR as the first compression system for their VLU
- Had at least 12 months' continuous medical history in their case record from the first mention of their VLU unless they healed.

Every patient in this cohort was assigned a random number. A representative sample of 250 TLCCB-treated patients was then generated by random selection of the random numbers of the whole cohort using a uniform distribution. The TLCCB-treated patients were matched with two randomly selected cohorts of TLCS-treated and CIBR-treated patients according to age at the start of treatment (±5 years), sex, and date of the start of treatment with their compression bandage (±2.5 years). This was achieved by identifying every TLCS-treated and CIBR-treated patient in the THIN dataset who matched these criteria. A representative sample of 250 patients per group was then generated by random selection from each cohort. No statistically significant differences were found between the different matched THIN cohorts when tested with either a Kruskal–Wallis test or Chi-squared test.

Study variables and statistical analyses

Information was systematically extracted from the patients' records over a period of 12 months from the start of compression and included:

- Age
- Sex
- Clinical outcomes
- Wound-related healthcare resource use
- Prescribed dressings
- Compression
- Medication.

It was assumed that if a patient received a dressing or bandage on a specific date, but a clinician visit was not documented in their record, the patient had been seen outside of the general practice by a district nurse.

Statistical analyses

Analysis of covariance (ANCOVA) was performed to enable differences in patients' outcomes between groups to be adjusted for any heterogeneity in age, sex, year the VLU started, time to the start of compression and comorbidities. Covariates that had a p-value of ≥0.05 were excluded from the ANCOVA model.

Kaplan–Meier analysis was undertaken to assess the probability of healing. This analysis found the healing distribution of the TLCCB-treated patients to be significantly different from the other two cohorts (Log Rank (Mantel–Cox): p=0.003) (Fig 2). The monthly rates of 'wound healing', 'improvement', 'remaining static' and 'infection' over 12 months in these cohorts were used to estimate the transition probabilities with which to populate the model (Table 1).

Logistic regression was used to investigate whether any of the baseline variables were independent predictors of any of the clinical outcomes.

All statistical analyses were performed using IBM SPSS Statistics (version 23.0; IBM Corp.,US).

Healthcare resource use

The amounts of healthcare resources documented in the patients' records to manage their VLU were quantified. These amounts varied according to whether the VLU was 'static', 'improving', 'infected' or 'healed'. Patients' healthcare resource utilisation was used to populate each health state in the model. This enabled healthcare resource use over 12 months from the start of treatment to be estimated.

Utilities

Utility scores express patient preferences for specific health states, which can be used to estimate a patient's HRQoL in terms of the number of quality-adjusted life years (QALYs) gained by an intervention or service. HRQoL was not recorded in the THIN database. Hence, published utility scores for VLUs, previously obtained from the general public across the UK using standard

Fig 2. Kaplan–Meier analysis. The healing distribution between the TLCCB group and the other two groups was significantly different (log rank (Mantel–Cox): p=0.003). TLCCB—two-layer cohesive compression bandage; TLCS—two-layer compression system; CIBR—cohesive inelastic bandage system

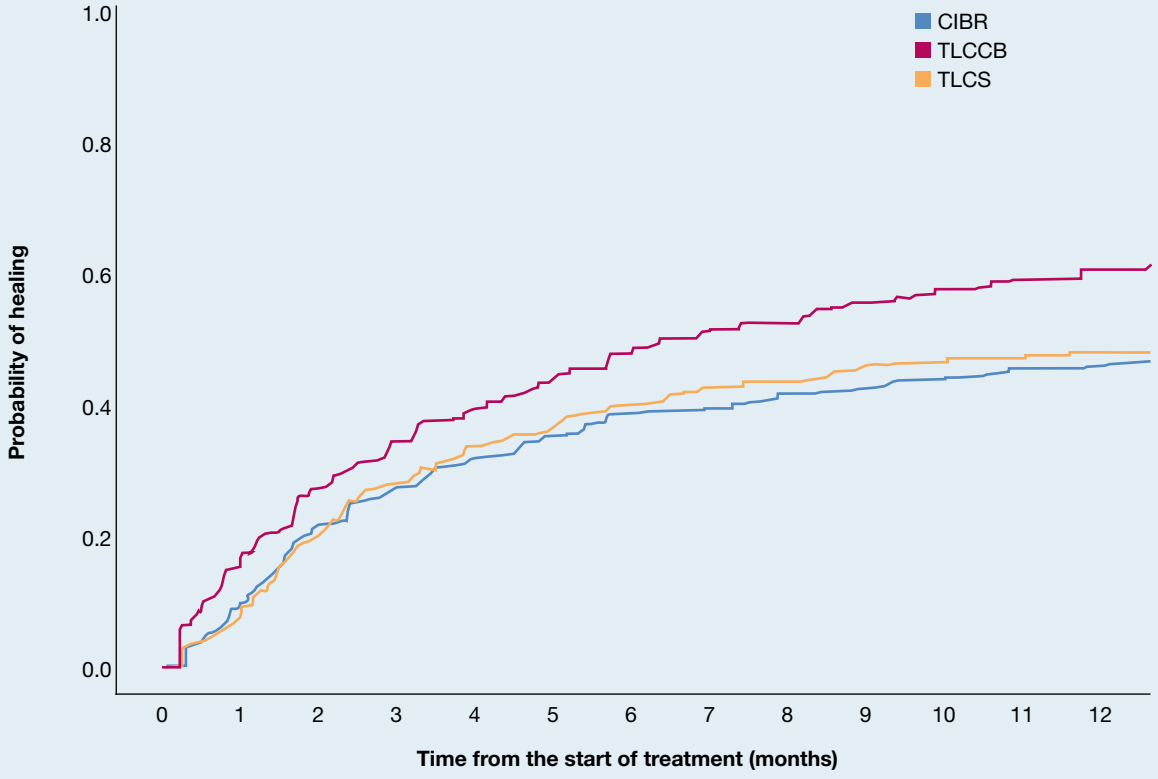


Table 1. Monthly transition probabilities in the Markov model

	TLCCB				TLCS				CIBR			
Month	**Static**	**Improving**	**Healed**	**Infected**	**Static**	**Improving**	**Healed**	**Infected**	**Static**	**Improving**	**Healed**	**Infected**
0	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
1	0.39	0.19	0.20	0.22	0.45	0.17	0.19	0.19	0.35	0.22	0.19	0.24
2	0.25	0.19	0.40	0.16	0.39	0.16	0.31	0.14	0.42	0.08	0.34	0.16
3	0.28	0.15	0.46	0.11	0.40	0.10	0.38	0.12	0.48	0.10	0.33	0.09
4	0.30	0.13	0.48	0.09	0.41	0.11	0.39	0.09	0.45	0.08	0.36	0.11
5	0.26	0.13	0.49	0.12	0.42	0.10	0.40	0.08	0.46	0.07	0.39	0.08
6	0.30	0.08	0.55	0.07	0.41	0.06	0.44	0.09	0.47	0.04	0.42	0.07
7	0.31	0.07	0.56	0.06	0.41	0.05	0.46	0.08	0.47	0.05	0.41	0.07
8	0.30	0.07	0.57	0.06	0.42	0.06	0.44	0.08	0.48	0.03	0.44	0.05
9	0.29	0.06	0.58	0.07	0.45	0.03	0.48	0.04	0.49	0.03	0.44	0.04
10	0.32	0.06	0.58	0.04	0.46	0.03	0.48	0.03	0.48	0.03	0.46	0.03
11	0.32	0.06	0.58	0.04	0.44	0.03	0.49	0.04	0.46	0.03	0.48	0.03
12	0.30	0.04	0.62	0.04	0.43	0.03	0.51	0.03	0.44	0.03	0.49	0.04

TLCCB—two-layer cohesive compression bandage; TLCS—two-layer compression system; CIBR—cohesive inelastic bandage system

gamble methodology, (0.64 for a static VLU, 0.73 for an improving VLU and 1.00 for a healed VLU),[13] were assigned to each health state in the model. This enabled patients' HRQoL in terms of the number of QALYs at 12 months from the start of treatment to be estimated.

Unit costs

NHS unit resource costs at 2020/21 prices[14–16] (Table 2) were applied to the healthcare resources populating each health state in the model to estimate the NHS cost of resource use attributable to managing a VLU over 12 months from the start of compression.

Model outputs

The primary measure of effectiveness was patients' health status in terms of the number of QALYs at 12 months. The secondary measure was the probability of healing by 12 months from the time patients entered the model.

The total NHS cost of VLU management over 12 months from the time patients entered the model was estimated at 2020/21 prices.

Cost-effectiveness analyses

The relative cost-effectiveness of the three compression systems was calculated as the difference between the total VLU management costs of two treatment groups divided by the difference in the number of QALYs between the same two groups and expressed as the incremental cost per QALY gained. If one of the compression systems generated more QALYs for less cost it was considered to be the dominant (cost-effective) intervention.

Sensitivity analyses

To assess uncertainty, probabilistic sensitivity analysis was undertaken. This involved generating 10,000 iterations of the model by simultaneously varying the different inputs. To estimate the random values of the inputs, the standard error was assumed to be 20% around the mean values but 10% around the utility scores (bounded by 0 and 1.0). Relevant distributions were assigned to the deterministic values (beta distributions for probabilities and utilities, and gamma distributions for resource use and costs), enabling the distribution of costs and QALYs to be estimated. This analysis enabled an estimation of the probability of the three compression systems being cost-effective at different cost per QALY thresholds.

Deterministic sensitivity analyses were also performed to assess the effect of independently varying the values of individual parameters within the model by 20% above and below the base case values, and varying the utility scores simultaneously by up to 10% above and below the base case values (but bounded by 0 and 1.0). These analyses identified how the relative cost-effectiveness of the alternative treatments change when varying individual parameters in the model.

Table 2. Unit resource costs at 2020/21 prices[14–16]

Resource	Unit cost, £
Practice nurse visit	22.00
District nurse visit	55.00
Podiatrist visit	26.00
GP visit	78.00
Hospital outpatient visit	230.00
Hospital admission	2475.00
Accident and emergency attendance	170.00
Compression hosiery	17.88
Analgesics per prescription	5.40
Antibiotics per prescription	5.43
Average dressing	3.60
TLCCB per bandage	10.52
TLCS per bandage	9.49
CIBR per bandage	4.85

GP—general practitioner, TLCCB—two-layer cohesive compression bandage; TLCS—two-layer compression system; CIBR—cohesive inelastic bandage system

Results

Patient characteristics

The study population comprised 750 patients in accordance with the inclusion/exclusion criteria and matching criteria (n=250 per group). There were no significant differences in patients' age, sex, body mass index, comorbidities, smoking status, and time from wound onset to starting compression between the three groups (Table 3). The time from wound onset to starting compression was a mean of two months in all three groups, which is consistent with current guidelines.

Patient management and outcomes

Outputs from the model indicated that the probability of healing in the TLCCB group was 0.62 by 12 months, compared with 0.51 and 0.49 in the TLCS and CIBR groups, respectively (Table 4). Hence, treatment with TLCCB is expected to increase the probability of healing by at least 20%. Nevertheless, the time to healing was comparable in all three groups (Table 4). These findings are reflected in the QALY analysis, which estimated that patients in the TLCCB group are expected to experience a better HRQoL than those in the other two groups (Table 4).

Logistic regression found that the independent risk factors for non-healing were a prior myocardial infarction, smoking and time to the start of compression (Table 5). Logistic regression also found that the independent risk factors for developing an infected VLU were the presence of moderate/severe liver disease, smoking, time to the start of compression and number of comorbidities (Table 6).

Table 3. Characteristics of the patients in the model

Characteristic	TLCCB	TLCS	CIBR
Age, years, mean (95% CI)	70.2 (68.3, 72.1)	72.4 (70.5, 74.0)	71.4 (69.9, 73.6)
Female, %	55.0	55.0	58.0
BMI, kg/m^2, mean (95% CI)	26.9 (26.1, 27.7)	27.1 (26.4, 27.9)	27.8 (27.0, 28.6)
Smoking status, %			
Smoker	23.0	23.0	18.0
Non-smoker	64.0	65.0	72.0
Unknown	13.0	12.0	10.0
Comorbidities, %			
Cardiovascular	32.0	38.0	36.0
Respiratory	26.0	36.0	29.0
Endocrinological	24.0	28.0	31.0
Gastrointestinal	17.0	18.0	14.0
Dermatological	14.0	26.0	18.0
Genitourinary	14.0	11.0	12.0
Musculoskeletal	13.0	10.0	7.0
Ophthalmological	12.0	17.0	16.0
Neurological	10.0	19.0	12.0
Psychiatric	9.0	12.0	11.0
Cancer	9.0	17.0	10.0
ABPI reported in patient record, %	18.0	22.0	16.0
Time from wound onset to start of compression, months, mean (95% CI)	2.1 (1.8, 2.4)	2.1 (1.9, 2.4)	2.4 (2.1, 2.8)

TLCCB—two-layer cohesive compression bandage; TLCS—two-layer compression system; CIBR—cohesive inelastic bandage system; CI—confidence interval; BMI—body mass index; ABPI—ankle–brachial pressure index

Table 4. Health outcomes

Outcome	TLCCB	TLCS	CIBR
Probability of VLU being healed at 12 months (95% CI)	0.62 (0.59, 0.64)	0.51 (0.49, 0.53)	0.49 (0.47, 0.50)
Probability of VLU having improved at 12 months (95% CI)	0.04 (0.03, 0.04)	0.03 (0.03, 0.03)	0.03 (0.03, 0.03)
Probability of VLU being static at 12 months (95% CI)	0.31 (0.28, 0.33)	0.43 (0.41, 0.45)	0.44 (0.42, 0.45)
Probability of VLU being infected at 12 months (95% CI)	0.03 (0.03, 0.04)	0.03 (0.03, 0.03)	0.04 (0.04, 0.04)
Probability of VLU having been infected over the 12 months (95% CI)	0.54 (0.52, 0.56)	0.56 (0.54, 0.58)	0.59 (0.57, 0.61)
Time to VLU healing, months, mean (95% CI)	3.70 (3.68, 3.72)	3.90 (3.88, 3.92)	3.80 (3.78, 3.82)
Number of QALYs per patient at 12 months, mean (95% CI)	0.86 (0.85, 0.87)	0.83 (0.82, 0.83)	0.82 (0.81, 0.83)

TLCCB—two-layer cohesive compression bandage; TLCS—two-layer compression system; CIBR—cohesive inelastic bandage system; VLU—venous leg ulcer; CI—confidence interval; QALY—quality-adjusted life year

Healthcare resource use

Patients' leg ulcers were predominantly managed by district nurses and, to a lesser extent, by practice nurses. Due to the higher healing rate in the TLCCB group, the mean amount of healthcare resource use attributable to managing VLUs treated with this compression bandage was less than that used to manage the VLUs treated with the other compression systems (Table 7). Less than

a quarter of all the patients had a Doppler ankle–brachial pressure index (ABPI) recorded in their records (Table 3) and 14%, 19% and 16% of patients in the TLCCB, TLCS and CIBR group, respectively, had undergone (documented) debridement. Additionally, 12%, 15% and 7% of patients in the TLCCB, TLCS and CIBR group, respectively, switched from their initial compression bandage to another compression system.

Healthcare cost of patient management

The total cost of leg ulcer management over the 12 months was estimated to be £3693 per VLU in the TLCCB group which was 16–17% lower than the cost of managing VLUs in the TLCS group (£4451 per VLU) and CIBR group (£4399 per VLU) (Table 8). The primary cost driver was district nurse visits, which accounted for up to 50% of the cost of managing VLUs in all three groups. Compression bandaging and hosiery accounted for up to 18% of the total NHS cost of wound management in all three groups (Table 8).

Cost-effectiveness analyses

Use of TLCCB resulted in a lower 12-month NHS wound management cost and more QALYs than were observed following the use of the other two compression systems. Hence, starting treatment with TLCCB was found to be the dominant strategy. Starting treatment with TLCS instead of CIBR resulted in more QALYs, but an additional cost, with an ensuing cost per QALY gain of £5200 (Table 9).

Sensitivity analyses

Probabilistic sensitivity analyses highlighted the distribution in the incremental costs and QALYs at 12 months between the three treatment strategies (Fig 3). The graph indicated that the majority of samples for the comparisons with TLCCB were located in the bottom right-hand (dominant) quadrant. However, the majority of samples for the comparison of TLCS with CIBR were located in the upper right- and left-hand quadrants. Outputs from the analysis showed that at a cost-effectiveness threshold of £20,000 per QALY:

- Up to 91% of a cohort is expected to be treated cost-effectively with TLCCB compared with TLCS
- Up to 98% of a cohort is expected to be treated cost-effectively with TLCCB compared with CIBR
- Up to 58% of a cohort is expected to be treated cost-effectively with TLCS compared with CIBR.

Deterministic sensitivity analyses in the form of tornado diagrams were performed on all model inputs, but only the main findings have been presented (Fig 4). These analyses showed that the relative cost-effectiveness of the different compression systems was very sensitive to changes in healing rates, utility values, acquisition costs and district nurse visits. Notwithstanding these findings, TLCCB remained a dominant treatment even when the value of these parameters was changed by ±20% around base case values and ±10% around the utility scores. Consequently, initial use of TLCCB in the treatment of VLUs remained a cost-effective technology since its relative cost-effectiveness remained <£20,000 per QALY.

TLCS remained a cost-effective treatment compared with CIBR for plausible changes in all the parameters with one exception. If the healing rate was decreased by 5% in the TLCS group or increased by 5% in the CIBR group, then CIBR would become the cost-effective treatment since it would achieve a cost per QALY gain of <£20,000.

Table 5. Linear regression assessing the impact of baseline variables on wound healing

Parameter	Odds ratio (95% CI)	p-value
Myocardial infarction	0.29 (0.12, 0.71)	0.007
Smoking	0.74 (0.55, 0.98)	0.036
Time to start of treatment	0.92 (0.87, 0.98)	0.004

CI—confidence interval

Table 6. Linear regression assessing the impact of baseline variables on developing an infected VLU

Parameter	Odds ratio (95% CI)	p-value
Moderate/severe liver disease	2.82 (1.02, 7.81)	0.047
Smoking	1.56 (1.18, 2.08)	0.002
Time to start of treatment	1.11 (1.05, 1.17)	<0.001
Number of comorbidities	1.10 (1.03, 1.17)	0.004

VLU—venous leg ulcer; CI—confidence interval

Table 7. Mean amounts of healthcare resource use per VLU over 12 months from the start of compression

Healthcare resource	TLCCB	TLCS	CIBR
District nurse visits	31.9	38.3	39.8
Practice nurse visits	9.1	11.0	11.5
GP visits	5.9	7.1	7.3
Analgesic prescriptions	2.0	2.0	2.0
Hospital outpatient visits	0.5	0.6	0.6
Podiatrist visits	0.3	0.4	0.4
Antibiotic prescriptions	0.3	0.3	0.3
Hospital admissions	0.1	0.2	0.2
Accident and emergency attendances	0.1	0.1	0.1
Compression bandages	39.0	48.0	50.0
Compression hosiery	13.6	17.4	18.3
Dressings	35.6	46.2	47.1

TLCCB—two-layer cohesive compression bandage; TLCS—two-layer compression system; CIBR—cohesive inelastic bandage system; GP—general practitioner

Table 8. Mean costs of healthcare resource use per VLU over 12 months from the start of compression

Characteristic	TLCCB, £ (% of total cost)	TLCS, £ (% of total cost)	CIBR, £ (% of total cost)
District nurse visits	1752.62 (47)	2106.61 (47)	2187.33 (50)
GP visits	460.40 (12)	551.79 (12)	568.67 (13)
Compression bandages	420.19 (11)	460.40 (10)	248.09 (6)
Hospital admissions	340.62 (9)	436.64 (10)	459.33 (10)
Compression hosiery	242.40 (7)	311.83 (7)	327.51 (7)
Practice nurse visits	200.69 (5)	242.17 (5)	252.44 (6)
Dressings	128.27 (3)	162.18 (4)	169.79 (4)
Hospital outpatient visits	117.43 (3)	146.24 (3)	152.41 (3)
Accident and emergency attendances	12.50 (<1)	15.93 (<1)	16.72 (<1)
Prescribed drugs	9.21 (<1)	7.57 (<1)	6.65 (<1)
Podiatrist visits	8.29 (<1)	9.86 (<1)	9.98 (<1)
Total	3692.62 (100)	4451.22 (100)	4398.92 (100)

TLCCB—two-layer cohesive compression bandage; TLCS—two-layer compression system; CIBR—cohesive inelastic bandage system; GP—general practitioner

Discussion

This study estimated the relative cost-effectiveness of three different compression systems in accordance with the Consolidated Health Economic Evaluation Reporting Standards (CHEERS).[17] The study adopted a Markov modelling approach since that was considered the most representative way to simulate patients' transition between different health states over a 12-month period. It was decided to model VLU management over a time horizon of 12 months since that allowed sufficient time to reflect a patient's journey in the real world.

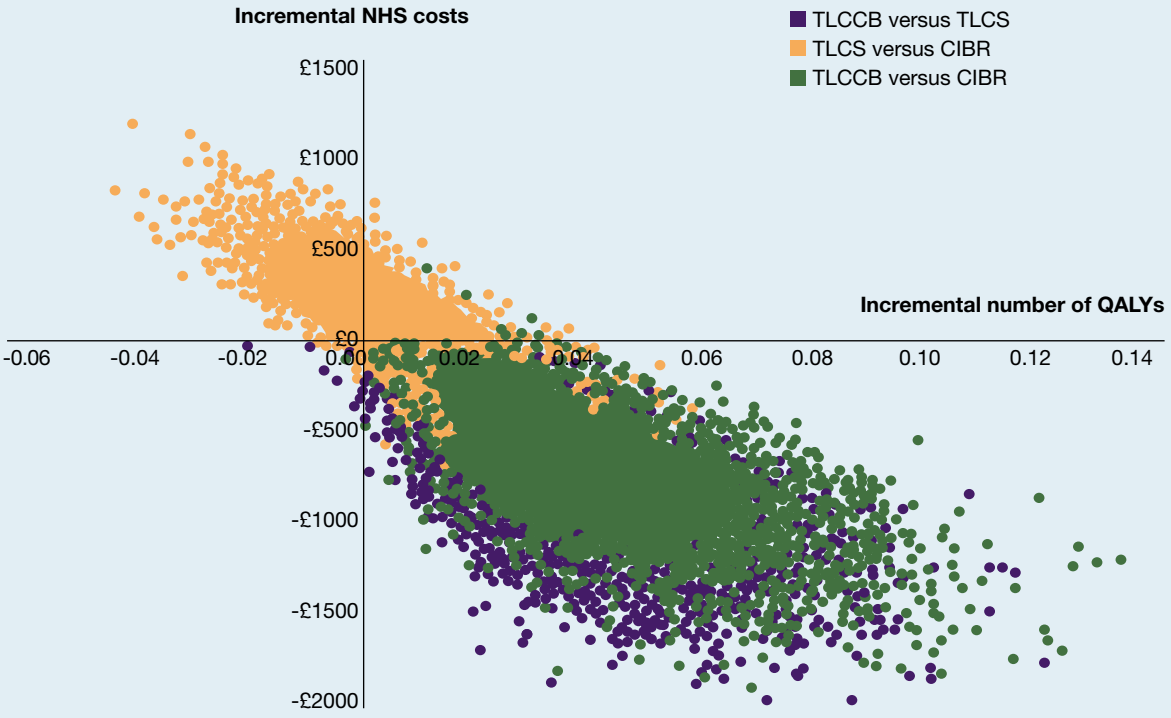
The resulting model was based on a direct comparison of a cohort of patients randomly extracted from the THIN database who had their leg ulcer initially treated with TLCCB, TLCS or CIBR in clinical practice in the UK. It is notoriously difficult to power health economic studies where the metric is use of different resources or

Table 9. Cost-effectiveness analysis

	Mean VLU management cost per patient over 12 months from the start of compression, £ (95% CI)	Mean number of QALYs per patient at 12 months from the start of compression, n (95% CI)	Incremental cost-difference, £ (95% CI)	Incremental QALY difference, (95% CI)	Incremental cost per QALY gained, £ (95% CI)
TLCCB	3693 (3607, 3786)	0.86 (0.85, 0.87)			
TLCS	4451 (4355, 4552)	0.83 (0.82, 0.83)			
CIBR	4399 (4295, 4505)	0.82 (0.81, 0.83)			
TLCCB versus TLCS			–758 (–822, –692)	0.03 (0.03, 0.04)	Dominant (–25,267) (–26,882, –18,433)
TLCS versus CIBR			52 (–5, 112)	0.01 (0.005, 0.01)	5200 (–1140, 11,464)
TLCCB versus CIBR			–706 (–766, –641)	0.04 (0.04, 0.05)	Dominant (–16,760) (–19,528, –14,812)

TLCCB—two-layer cohesive compression bandage; TLCS—two-layer compression system; CIBR—cohesive inelastic bandage system; QALY—quality-adjusted life year; CI—confidence interval

Fig 3. Scatterplot of the incremental cost-effectiveness of (1) TLCCB compared with TLCS; (2) TLCS compared with CIBR; and (3) TLCCB compared with CIBR following 10,000 iterations of the model. TLCCB—two-layer cohesive compression bandage; TLCS—two-layer compression system; CIBR—cohesive inelastic bandage system; QALYs—quality-adjusted life years; NHS—UK National Health Service

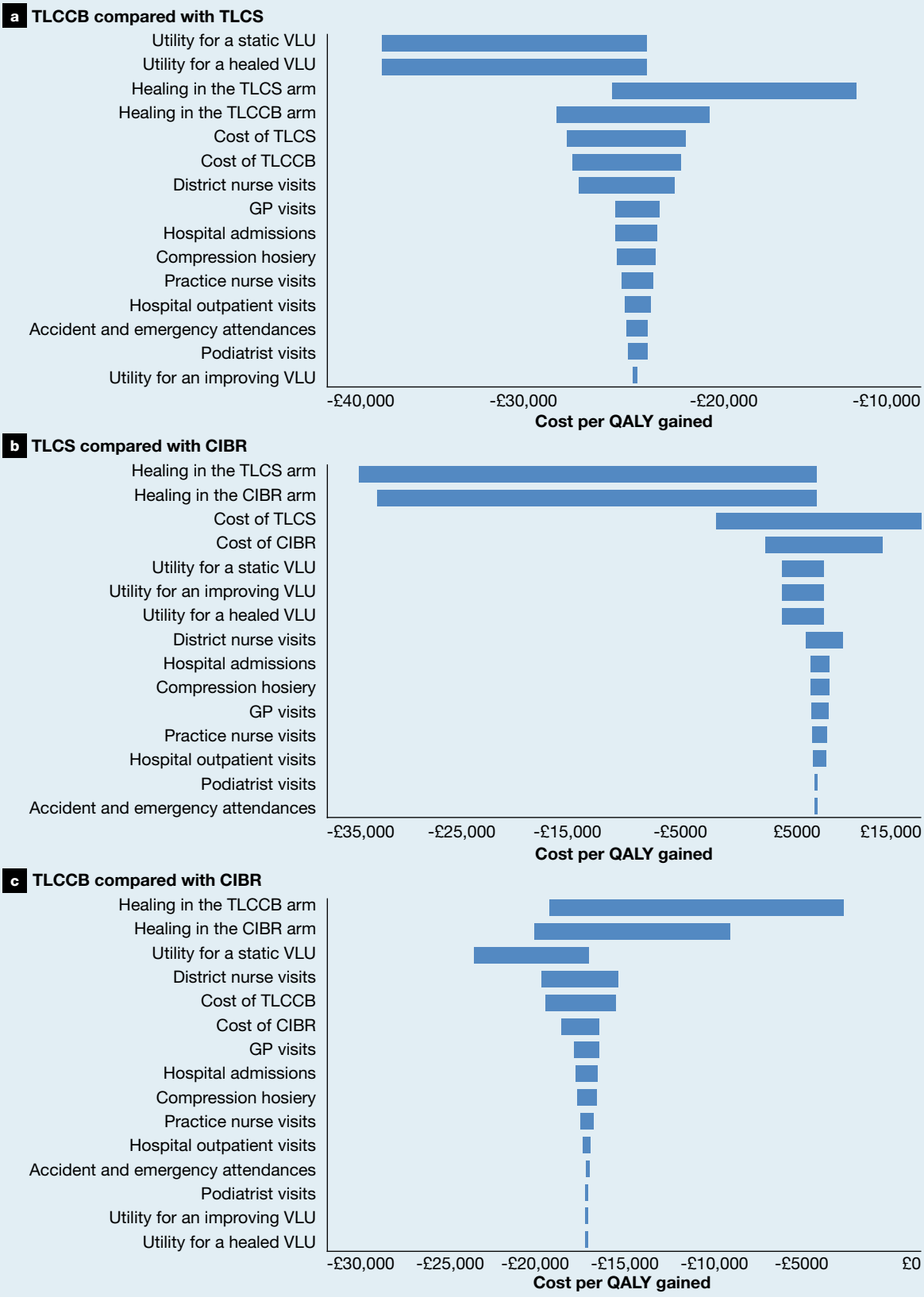


a range of clinical outcomes, which are unknown at the outset. However, power calculations showed that this sample size was sufficiently large to detect the observed differences in healing with 90% power and a type I (alpha) error of 0.05 between the groups. Against this background, TLCCB was found to be clinically more effective and more cost-effective than the other two compression systems in treating newly diagnosed VLUs. Kaplan–Meier analysis of the THIN dataset found that 22% and 27% more wounds healed in the TLCCB group than in the TLCS and CIBR groups, respectively (p=0.003). Additionally, the model indicated that patients in ~~the~~ TLCCB group were expected to experience a better HRQoL and their wound management cost was expected to be 16–17% less than that to manage VLUs in the other two groups. This finding is consistent with our previous studies which also assessed the relative cost-effectiveness of TLCCB in managing VLUs.[18,19]

The healing rates in this study were lower than those seen in our previous study comparing the use of TLCCB with TLCS in clinical practice,[19] but comparable to those seen in several other studies.[20–24] The inevitable variation between healing rates reported in different studies and the differences observed between the three groups in our study may reflect the practical difficulties experienced by non-specialist nurses in the community in achieving the correct levels of compression, as well as the lack of specialist involvement.[2,6,25,26] These differences may also highlight some of the practical problems associated with wound care in the community and the lack of skills required to both select and apply appropriate compression therapy.[2,6,25,26] For example, <25% of all patients in our dataset appeared to have undergone a Doppler ABPI measurement, contrary to national guidance.[27,28] While this may be indicative of the difficulties experienced by non-specialist health professionals in the community in acquiring necessary skills or accessing Doppler equipment, it also raises a question pertaining to the accuracy of the VLU diagnosis. Notwithstanding this, the patients had a VLU diagnosis documented in their records and they were managed with compression as if they had a VLU. Hence, the findings from this study reinforce the importance of training non-specialist nurses in the diagnosis and appropriate management of VLUs, and in the application of compression systems in order to overcome some of the problems encountered in clinical practice and achieve better patient health outcomes than those currently observed.

Up to 15% of patients in our THIN dataset switched

Fig 4. Tornado analysis showing the influence of increasing or decreasing key variables by up to 20% on the incremental cost per quality-adjusted life year (QALY) gained; TLCCB—two-layer cohesive compression bandage; TLCS—two-layer compression system; CIBR—cohesive inelastic bandage system; VLU—venous leg ulcer; GP—general practitioner



from their initial compression system a mean of 2–3 months after starting treatment. Consequently, a minority of patients would not have been receiving their initial compression system at the end of the study period and thus may not have been healed by that compression system. Nevertheless, economic analysis considers the costs and consequences of the initial decision. Hence, this outcome is a consequence of the initial decision to treat with TLCCB, TLCS or CIBR and is reflected in the costs, healing rates and QALYs for each group.

Limitations

The advantages and disadvantages of using patients' records in the THIN database for economic evaluations in wound care have been discussed elsewhere.[2,6,18] In summary, the advantage of using the THIN database is that the patient pathways and associated resource use are based on real-world evidence derived from clinical practice. However, patients were not randomised to their received treatment. Hence, there may have been differences between the groups resulting in the clinician's decision to treat with one of the three compression systems and the patient's willingness to accept the clinician's preferred treatment. Hence, the possibility that undetected differences exist between the matched cohorts cannot be excluded, which may explain, in part, the different healing rates.

Other limitations, in particular, should be considered when interpreting this study's findings. The analyses were based on clinicians' entries into their patients' records and inevitably subject to a certain amount of imprecision and lack of detail. Consequently, wound size, wound severity and exudate levels were not included in the matching criteria, since they were not fully documented in the patients' records. Prescriptions issued by GPs and practice nurses were recorded in the database, but it does not specify whether the prescriptions were dispensed or detail patient adherence with the product. The THIN database may have under-recorded use of some healthcare resources outside the GP surgery if they had not been documented in the general practice records. Despite these limitations, it is the authors' opinion that the THIN database affords one of the best sources of real-world evidence for clinical practice in the UK. This view is supported by the publication of >1938 research articles in peer-reviewed journals that use this database as the source of their underpinning evidence.[29]

The analysis only considered NHS resource use and associated costs for the 'average patient' since there were insufficient data to assess the relative cost-effectiveness of the three compression systems in particular subgroups. The study results were truncated at 12 months, and excluded the costs and consequences of managing patients with an unhealed ulcer beyond this period. Patients' costs and indirect societal costs as a result of patients being absent from work were also excluded from the analysis. However, patients' mean age was >65 years, so it is unlikely that many were in employment.

The analysis was unable to consider the impact of other factors that may have affected the results, such as wound size and severity of underlying venous disease. Additionally, the analysis was unable to incorporate any intangible benefits that patients may have experienced following use of the different compression systems, irrespective of whether their wound healed. It should also be borne in mind that the analysis was unable to consider the level of a clinician's skills in administering each of the compression systems and was unable to discern the challenges clinicians may have in the community in applying compression. Ideally, a compression bandage system should stay in place for the duration of wear because slippage leads to a failure to deliver the required level of compression. However, many compression bandages slip down the limb becoming bunched and uncomfortable, resulting in a loss of compressive ability.[10,30] TLCCB has been reported as eliciting more consistent pressures than other compression systems,[31] and to be associated with lower slippage as well as maintaining resting pressures and amplitudes at values known to be effective for ulcer healing.[10,32] This may explain, in part, the differences in healing rates observed among the patients in this study's THIN dataset.

Despite these limitations, all the patients in this dataset had a VLU diagnosis, and were predominantly managed locally by district and practice nurses. This is consistent with the findings from previous studies on the management of VLUs.[2,6,18,25,26,33–36] Furthermore, the 12-month cost of patient management is concordant with our previous studies on the cost of managing VLUs in clinical practice.[2,6,18,25,26,33–36] VLU management remains challenging, with an estimated 330,000 new VLUs and 230,000 hard-to-heal VLUs in the UK in 2017/18.[2] The majority of expenditure for managing these wounds is expected to comprise district and practice nurse visits. However, the cost of managing an unhealed VLU has been estimated at being 3–4 times greater than that of managing a wound that heals.[2] The VLUs that remained unhealed at 12 months in this study's cohort will have become hard-to-heal wounds and there is an accumulating pool of patients with such leg ulcers.[2,25,26] In this regard, the study provides supportive evidence of the potential role that TLCCB can play in reducing the ever increasing burden that VLUs impose on the UK's NHS.[2]

Conclusion

In conclusion, within the study's limitations, starting treatment of newly diagnosed VLUs with TLCCB instead of the other two compression systems appears to afford a more cost-effective use of NHS-funded resources in clinical practice, since it is expected to result in an increased healing rate, better HRQoL and a reduction in NHS leg ulcer management cost. JWC

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Reflective questions

- What challenges do you face in diagnosing and appropriately managing a venous leg ulcer (VLU)?
- What difficulties do you have in applying compression to a VLU?
- Do you think you achieve the requisite level of pressure when you apply compression to a VLU? If not, how could this be achieved?