Randomized trial

Randomized clinical trial and economic analysis of four-layer compression bandaging for venous ulcers

J. F. O'Brien[1], P. A. Grace[1,3], I. J. Perry[4], A. Hannigan[3], M. Clarke Moloney[1] and P. E. Burke[1,2]

Department of Vascular Surgery, [1]Mid-Western Regional Hospital, [2]St John's Hospital, [3]Department of Mathematics and Statistics, University of Limerick, Limerick and [4]Department of Epidemiology and Public Health, University College Cork, Cork, Ireland

Correspondence to: Mr P. E. Burke, Department of Vascular Surgery, St John's Hospital, Limerick, Ireland (e-mail: vsherlock@mwhb.ie)

Background: The aim of this study was to compare the cost-effectiveness of four-layer compression bandaging for venous leg ulcers with that of other available treatments.

Methods: In this pragmatic trial, 200 patients with a venous leg ulcer were randomized either to four-layer bandaging (intervention group; $n = 100$) or to continue their usual system of care (control group; $n = 100$). The follow-up for each patient was 12 weeks. Analysis was by intention to treat; the main outcome measures were time to healing and cost to the health board per leg healed.

Results: Baseline characteristics were well matched in the two groups. The Kaplan–Meier estimate of the healing rate at 3 months was 54 per cent with four-layer bandaging and 34 per cent in the control group. Throughout the 3 months, four-layer bandaging healed leg ulcers significantly earlier ($P = 0{\cdot}006$). There was a significant reduction in the median cost per leg healed with four-layer bandaging (€210 *versus* €234; $P = 0{\cdot}040$).

Conclusion: Four-layer bandaging is currently the most effective method of treating venous leg ulcers in a community setting.

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Introduction

Compression, in the form of the four-layer bandaging is the recommended treatment for venous leg ulcers[1,2], but the efficacy of this treatment remains unclear[3]. Initial studies lacked valid controls. Three-month healing rates of between 69 and 74 per cent were reported in patients treated with four-layer bandaging in specialized clinics[1,4]; these rates compared with around 20 per cent in patients receiving traditional care[1,4,5]. In contrast, results from a recent randomized controlled trial in the community suggest a more modest clinical difference in healing rates between four-layer bandaging (34 per cent) and control treatment (24 per cent), with no significant difference in cost-effectiveness[6].

The lack of sound evidence has led some budget-holders to question the wisdom of financing the relatively expensive four-layer bandage package in Ireland. The aim of this study was to compare the cost-effectiveness of four-layer bandaging with that of alternative dressings available for venous leg ulcers in a pragmatic randomized clinical trial.

Patients and methods

Patients were included in the trial if they had a venous leg ulcer and were not being treated with four-layer bandaging. Public health nurses, practice nurses and general practitioners (GPs) referred patients in the community with a suspected venous ulcer. These patients received written information about the study and were invited for assessment. Assessment was undertaken by a research officer at patients' homes, at local health centres or at the Mid-Western Regional Hospital. A venous ulcer was defined when there was clinical evidence of venous disease, the resting ankle : brachial pressure index was 0·9 or greater, and no other cause was identified. Patients meeting the inclusion criteria were invited to enrol in the trial and written consent was obtained. Recruitment was from April 1999 to August 2000 when the required sample of 200 patients was achieved. The Research Ethics Committee at the Mid-Western Regional Hospital approved the trial.

In this prospective randomized clinical trial, patients were randomized to four-layer bandaging (intervention group) or to continue with their usual care (control group).

Before the study began, a random 'intervention' or 'control' list was generated for 200 patients by computer, and the results were entered sequentially into sealed numbered envelopes. These envelopes were assigned to consecutive patients once consent had been obtained. Information recorded at the recruitment phase included the age and sex of the patient, the duration of the ulcer, and any history of deep vein thrombosis (DVT), diabetes or rheumatoid arthritis. The ulcerated area was measured and photographed by the research officer. Each patient in the trial was followed for 12 weeks.

All patients had the leg ulcer dressed by the usual community nurse. Before the start of this study all public health nurses in this region underwent formal training in the application of four-layer bandaging; this was achieved by workshops and individual instruction. A standard four-layer bandage was used, comprising a sterile wound contact layer, a natural padding bandage, a light conformable bandage, a light compression bandage and a flexible cohesive bandage. This combined system provided sustained external compression of 40 mmHg at the ankle.

Ulcer healing

The primary outcome measure was time to heal the leg ulcer. In patients with bilateral leg ulcers, the leg with the larger surface area of ulceration was included in the analysis. Healing was defined as full epithelialization and no scab present. When complete healing occurred within the 12-week interval, a photograph of the site was taken to provide an objective review of outcome. If the patient's leg remained unhealed, the ulcer area was measured and photographed at the end of the trial.

Cost analysis

The main resource costs identified in the community treatment of venous leg ulcers in the large urban and rural region of the Mid-Western Health Board were dressing products, nurses' time, mileage expenses, and GP and hospital services. Nurses' time was collated in relation to dressing the leg ulcers, driving to patients' homes and administrative duties.

Information was gathered over the 12-week trial for each patient on the type and quantity of dressings and bandages used, the duration and frequency of dressing treatments, and the number of patient visits to hospital or to the GP specifically for leg ulcer treatment. The distance travelled by nurses from the health centre to patients' homes was established where applicable, and adjusted to take account of the fact that on average two other visits were made on a round trip. Travel time and administration time was estimated.

Dressings were costed using local pricing lists. The cost of nursing time was calculated using the average hourly salary rate for community nurses and included allowances. Mileage expenses were based on the middle engine car rate. GP services were estimated and the hospital finance department provided details on hospital costs.

Statistical analysis

The calculation of sample size was based on an estimated difference in healing rates at 12 weeks of 20 per cent (45 *versus* 25 per cent) between four-layer bandaging and alternative dressings. The probability of 0·8 of detecting such a difference at the 5 per cent significance level required 200 patients to be included.

Intention-to-treat analysis was carried out. Appropriate parametric and non-parametric summary statistics were calculated. The two-tailed Student t test and the Mann–Whitney U test were used to analyse differences in means and medians respectively. Healing rates were compared using the Kaplan–Meier method and healing times were adjusted for explanatory variables by Cox regression analysis.

Results

Baseline characteristics in the intervention (four-layer bandage) and control groups were similar (*Table 1*). Patient follow-up during the trial is described in *Fig. 1*. In view of the intention-to-treat analysis, information was gathered about patients who became non-compliant or dropped out of the trial. Missing data were minimized.

As this was a pragmatic study, leg ulcer treatment in the control patients was not standardized but was determined by the public health nurse or GP treating the patient.

Table 1 Baseline characteristics of 200 patients with a venous leg ulcer

	4LB ($n = 100$)	Control ($n = 100$)
Sex ratio (M : F)	35 : 65	33 : 67
Age (years)*	71·7(9·8)	71·4(11·5)
Size of leg ulcer (cm^2)†	3·5 (1·3–8·1)	2·7 (1·6–6·2)
Duration of leg ulcer (weeks)†	9 (4–27)	11 (5–28)
History of DVT in affected leg	15	9
Diabetes mellitus	3	5
Rheumatoid arthritis	1	2

Values are *mean(s.d.) or †median (interquartile range). 4LB, Four-layer bandaging; DVT, deep vein thrombosis.

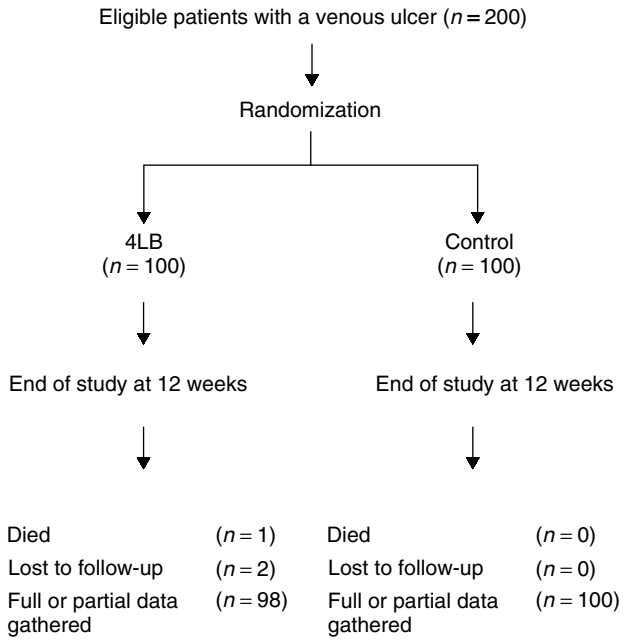
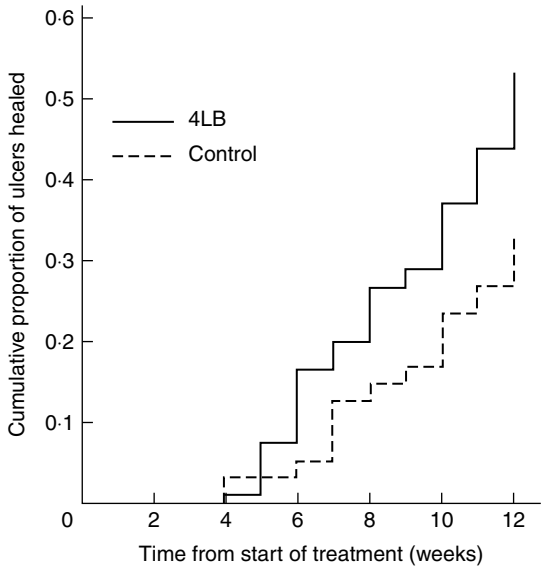


Fig. 1 Patient follow-up during trial. 4LB, four-layer bandaging



No. unhealed							
4LB	100	100	93	82	70	61	48
Control	100	100	98	92	80	75	66

Fig. 2 Time to healing in 200 patients with leg ulcers treated by four-layer bandaging (4LB) or control dressings. The rate of healing was significantly better with 4LB ($P < 0{\cdot}001$, log rank test)

Treatment in controls, therefore, included an assortment of topical dressings, such as hydrocolloids, alginates, paraffin and iodine dressings. Various absorbency dressings, low-pressure bandages and elasticated support were also used. One patient had laser therapy. Five patients in the control group had compression applied at some stage during the 3-month study interval. Twelve patients in the four-layer bandaging group were non-compliant; the main reason was intolerance to the high compression bandage. High-absorbency dressings ($n = 11$) and desloughing agents ($n = 8$) were used at the discretion of the nurse in some patients in conjunction with four-layer bandaging.

Ulcer healing

Leg ulcers treated with a four-layer bandage were 1·8 (95 per cent confidence interval (c.i.) 1·2 to 2·9) times more likely to have healed by 3 months than those subjected to control treatments. The Kaplan–Meier estimate of the proportion healed at 3 months was 54 per cent in the four-layer bandage group and 34 per cent in the control group ($P < 0{\cdot}001$) (*Fig. 2*). Healing rates were still significantly different between the two groups after adjusting for age, baseline ulcer area and duration, and history of DVT, rheumatoid arthritis and diabetes ($P = 0{\cdot}015$). The rate of healing throughout the 3 months was significantly better using four-layer bandaging ($P = 0{\cdot}006$, log rank test). The mean reduction in ulcer size was not significantly different between the two groups $-1{\cdot}1$ (95 per cent c.i. $-2{\cdot}9$ to $0{\cdot}7$) cm^2.

Table 2 Resources used to treat leg ulcers according to treatment group

	4LB ($n = 98$)‡	Control ($n = 100$)
No. of dressing treatments*	11·4(5·3)	20·1(8·0)
No. of home visits*	11·8(5·2)	20·4(7·7)
Nursing time (h)		
Dressing*	3·4(2·2)	5·3(2·7)
Administration*	1·7(0·4)	1·8(0·3)
Travel†	0·1 (0–0·8)	0·4 (0–1·7)
Total*	5·6(2·7)	8·0(3·3)
Distance travelled (miles)†	4·0 (0–32·0)	16 (0–66·0)

Values are *mean(s.d.) or †median (interquartile range). ‡Data missing for two patients. 4LB, four-layer bandaging.

Costs

Table 2 provides an overview of resources used in the treatment of leg ulcers during the study. Dressings were carried out more frequently and for longer in the control group, impacting strongly on nurses' time and travel.

Table 3 Costs per patient

	Cost per patient (€)	
	4LB ($n = 98$)‡	Control ($n = 100$)
Dressing products†	117·0 (70·2–137·2)	81·0 (46·0–136·0)
Nursing time		
Dressing†	53·0 (35·8–71·6)	90·0 (63·4–107·5)
Administration*	30·4(71·6)	32·6(6·0)
Travel†	1·77 (0–14·3)	7·2 (0–29·6)
Total*	99·6(49·1)	144·2(59·9)
Mileage†	2·0 (0–16·2)	8·1 (0–33·3)
Overall costs†	209·7 (137·5–269·4)	234·6 (168·2–345·1)

Values are *mean(s.d) or †median (interquartile range). ‡Data missing for two patients. 4LB, four-layer bandaging.

Overall, home treatment was provided for 63 per cent of patients who had four-layer bandaging and 72 per cent of patients treated with control dressings. Five patients in each group needed to visit the GP specifically for leg ulcer problems. One patient in the four-layer bandage group was admitted for hospital treatment.

The median cost of dressing materials was higher in patients who had four-layer bandaging (*Table 3*). Lower median nursing and travel expenses defrayed this extra cost when comparisons were made with findings for the control group. The use of GP and hospital services was minimal in either group; related costs fell as extreme values outside the interquartile ranges and were consequently omitted from *Table 3*. These latter costs were, however, included in the overall costings. The median cost per leg healed was significantly less for four-layer bandage treatment ($P = 0{\cdot}040$).

Discussion

The findings of this trial support the hypothesis that four-layer bandaging is the most effective treatment for venous leg ulcers, at no additional cost to the health service. Just over half of the ulcers in the trial healed within 3 months using four-layer bandage, almost twice the rate observed for alternative dressings.

The healing rate of 54 per cent at 3 months for four-layer bandaging in the present study was much lower than that in an earlier study at Charing Cross Hospital, London (69–74 per cent)[1,4], but higher than the 34 per cent reported later in the first randomized controlled trial that documented the cost-effectiveness of four-layer bandaging[6]. This may reflect the fact that most of the patients in the study had active leg ulceration for more than 8 weeks before randomization, in contrast to the Charing Cross Hospital study in which ulcers were present for less than 4 weeks[1]. Patients in the study by Morrell *et al.*[6], with lower healing rates, had active leg ulceration for at least 3 months before induction into the trial. The healing rate of 34 per cent among control patients in the present study was an improvement on previous findings[1,4,6], consistent with a general improvement in the practice of wound management.

While it is difficult to measure costs in a pragmatic study such as this, there was a statistically significant difference in the direct costs between four-layer bandaging and the opposing treatments. In absolute terms, this difference was relatively small, as has been shown previously[6]. There may have been some bias in the present study as more patients in the control group received home care, but this difference was not statistically significant. It is clear, however, that the opportunity costs associated with four-layer bandaging are much lower, with more time being made available to community nurses for other work.

Although cost data collated for this study were substantive and accurate, the economic evaluation was reviewed from the perspective of the health board only, and based on readily available costs. The broader indirect economic implications of venous leg ulcers were not considered, nor were the costs incurred by patients. These financial costs were expected to be small, as the majority of patients with a leg ulcer in Ireland are retired, and are in the General Medical Scheme[7].

The present randomized study has shown that four-layer bandaging is currently the most effective method of treating venous leg ulcers in a community setting, providing increased health benefits to patients at no added cost.

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