Multimodal wound care in infection continuum management: supporting antimicrobial stewardship through early intervention

Aim: Wound deterioration is recognised as occurring along an infection continuum, yet management often remains reactive, with intervention initiated only after clinical deterioration. This service evaluation assessed the impact of introducing a multimodal enzyme alginogel (Flaminal®, Flen Health) as the primary dressing at the earliest recognised signs of delayed healing, signs of biofilms and/or infection, as well as its associated impact on service costs and clinical capacity.

Method: Thirteen wounds from the caseload of patients being managed by the Skin Integrity Team Complex Wound Clinic at an NHS Foundation Trust were identified as experiencing signs of delayed healing, signs of biofilms and/or infection. A two-step approach was applied, comprising standard wound bed preparation followed by application of a multimodal enzyme alginogel (Flaminal®, Flen Health). Clinical outcomes were recorded weekly to week four. Patient and clinician experience was captured through a structured end-of-treatment review. A cost model compared the four weeks before and after implementation for 12 wounds.

Results: Eleven wounds (85%) had fully epithelialised by week four, rising to 92% when the single peri-wound moisture-associated skin damage case was excluded. Infection indicators reduced from 62% at baseline to none among wound-bed cases. Mean pain scores fell from 3.8 to 0.5, and no wound recorded moderate exudate at week four. The average total cost burden fell from £167.41 to £56.30 per patient per week, a reduction of 66%, and clinician time fell by 20 minutes per patient, a reduction of 33%.

Conclusion: Early structured multimodal intervention was associated with improved healing, resolution of infection indicators and reduced pain, alongside lower dressing costs and released clinical capacity. Findings support earlier intervention as a practical contribution to antimicrobial stewardship.

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Key words
- Infection
- Antimicrobial stewardship
- Flaminal®
- Multimodal intervention

Chronic wounds frequently fail to progress through the normal stages of healing despite appropriate treatment. A principal reason is microbial burden. Bacteria within the wound bed organise into biofilm communities that are structurally protected, tolerant of antimicrobial agents and difficult to eradicate once established (Percival et al, 2012; Almuhanna, 2025). Their presence sustains a prolonged inflammatory response, degrades the extracellular matrix and impairs the orderly progression of healing, leaving wounds stalled rather than closing (Schultz et al, 2003).

Wound deterioration is now widely understood as occurring along an infection continuum, progressing from contamination and colonisation through local infection to spreading and systemic infection (IWII, 2022). The value of this framework is that it identifies a window before overt infection develops, in which subtle changes such as delayed healing beyond expectations, increasing exudate, hypergranulation or friable, bleeding granulation tissue, may signal rising microbial burden before the classic signs of erythema in white skin tones or hyperpigmentation/colour change in brown and black skin tones, swelling and increasing pain become evident. Recognising and acting within that window offers the opportunity to proactively interrupt progression rather than respond to it (IWII, 2022).

In practice, however, management frequently remains reactive. Intervention is commonly initiated once deterioration is clinically obvious, by which point wounds may have stalled for weeks and systemic antimicrobials are more likely to be considered. This carries consequences for the patient, in prolonged healing times, pain and reduced

Declarations

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Conflicts of interest: The cost analysis model used to calculate the cost savings reported here was created by Flen Health.

quality of life, and for the service, in repeated dressing changes, higher product use and sustained demand on clinician time. It also sits uneasily alongside antimicrobial stewardship, which seeks to reduce avoidable antibiotic exposure and preserve the effectiveness of existing agents (Probst et al, 2022).

Topical, non-antibiotic options that address several barriers to healing simultaneously are therefore of interest as earlier interventions. A multimodal enzyme alginogel (Flaminal®, Flen Health) is a primary wound dressing that combines continuous autolytic debridement, antimicrobial protection and the ability to absorb excess exudate in a single product, allowing devitalised tissue, microbial burden and exudate to be addressed together rather than sequentially (White, 2014; **Table 1**). Whether introducing such a product at the first recognised signs of stalled healing improves outcomes, and what it means for service resources, has been less well described in routine practice.

Aim

To evaluate the impact of structured early intervention with a multimodal enzyme alginogel (Flaminal®, Flen Health) on progression along the infection continuum in wounds presenting with delayed healing, and to assess the associated effect on wound care costs, healthcare professional time and clinical capacity.

Method

Design and setting

This was a service evaluation undertaken by the Skin Integrity Team (SIT) at Doncaster and Bassetlaw Teaching Hospitals NHS Foundation Trust (DBTH). The evaluation assessed the introduction of a multimodal enzyme alginogel (Flaminal®, Flen Health) at the earliest recognised signs of biofilm and/or infection, or stalled healing, and compared clinical outcomes and service resource use before and after the change in pathway. As the work constituted an evaluation of an existing service rather than research, formal ethics approval was not required.

Cohort

Thirteen wounds were included. Following discharge from DBTH, all patients were referred to the SIT complex wound clinic as Tier 3 wounds, characterised by non-healing status, ≥50% devitalised, sloughy or necrotic tissue that required management involving both generalist and specialist services. Baseline characteristics are shown in **Table 2**. Wounds were predominantly surgical or dehisced surgical in origin, and duration prior to intervention ranged from four days to 52 weeks, with 62% classified as chronic (defined as wounds present for ≥12 weeks). At baseline, eight wounds (62%) demonstrated recorded clinical indicators of local infection. In the remaining five, overt infection was not documented but features consistent with biofilm presence were recorded, including delayed healing beyond expectations, persistent inflammation, peri-wound colour change at the wound edge, new or increased pain, and exudate changes consistent with microbial burden (IWII, 2022). The cohort therefore represented wounds affected either by overt local infection or by biofilm-driven stalled healing.

No restriction was applied to wound aetiology, wound duration, patient age or comorbidity, in order to reflect the range of wounds seen in routine practice. All eligible wounds were included in the clinical analysis; one wound was subsequently excluded from the cost analysis only, as described below.

Prevention of biofilm formation was recorded as a treatment aim in every case, confirming that control of microbial burden

Table 1. Multimodal mechanism of action of enzyme alginogel (Flaminal®, Flen Health).

A simultaneous multimodal approach addresses key barriers to healing, supporting bioburden control and creating conditions less conducive to biofilm reformation, in line with wound bed preparation principles (Schultz et al, 2003; Gottrup et al, 2013; White, 2014).

Mechanism	Effect	Clinical implication
Autolytic debridement	Removes devitalised tissue	Reduces barriers to healing
Enzyme-based antimicrobial protection	Reduces microbial burden, with no resistance recorded to date	Supports antimicrobial stewardship
Moisture balance	Absorbs exudate, maintaining a moist wound environment	Supports healing progression

Table 2. Baseline cohort characteristics (n=13 wounds).

Characteristic	Value
Wounds evaluated	13
Sex	Female 11 (85%); male 2 (15%)
Age, mean (range)	49 years (21–79)
Wound aetiology	Surgical or dehisced surgical 11 (85%); haematoma 1 (8%); peri-wound moisture-associated skin damage 1 (8%)
Wound duration prior to intervention	Range 4 days – 52 weeks; chronic 62% (≥12 weeks)
Wound condition prior to infection or biofilm	Static 10 (77%); deteriorating 2 (15%); healing 1 (8%)
Baseline pain, mean VAS	3.8
Exudate level	Low 8 (62%); moderate 5 (38%)
Clinical indicators of local infection present	8 (62%)
Suspected biofilm / unexplained delayed healing	5 (38%)
Debridement before first application	2 (15%)
Self-care or shared care in place	7 (54%)
Primary treatment aim	Wound filler 12 (92%); moisture balance 1 (8%)
Secondary treatment aim	Prevent biofilm formation 13 (100%)
Alginogel formulation	Forte 12 (92%); Hydro 1 (8%)
Dressing change frequency	Every 3–4 days, all wounds

was an explicit clinical intention at the point of intervention rather than a retrospective interpretation.

Intervention

A two-step multimodal approach was applied. Step one comprised standard wound bed preparation, including cleansing and mechanical debridement where clinically indicated (Schultz et al, 2003). Step two comprised application of a multimodal enzyme alginogel (Flaminal®, Flen Health), selected for its combined action on devitalised tissue, microbial burden and moisture balance [Table 1]. Dressings were changed every three to four days across the cohort. Debridement prior to first application was undertaken in two cases, and self-care or shared care arrangements were in place for seven wounds, reflecting variation in routine clinical practice rather than protocolised management.

Outcome measures

Clinical outcomes were recorded at baseline and weekly to week four, and comprised healing progression and tissue type, presence of indicators of bioburden or local infection, pain measured using a visual analogue scale (VAS), exudate level and type, wound edge condition, and wound surface area and depth. Healing was inferred where a wound no longer appeared in the following week of data.

Patient and clinician experience was captured at the end of the treatment period using a structured review. Patient-reported items covered pain or discomfort during and after dressing changes, whether the enzyme alginogel was felt to have reduced or prevented wound-related pain, reduction in wound-related stress such as fear of dressing changes, odour or pain, effectiveness of treatment compared with previous management, and a quality-of-life score recorded using the quality of life tool developed by Joy Tickle, Tissue Viability Nurse Consultant at Hampshire and Isle of Wight Healthcare. Clinician-reported items covered whether the enzyme alginogel remained in place between dressing changes, any change in dressing change frequency during treatment, the extent to which the primary, secondary and tertiary treatment aims were met, willingness to recommend the product to a colleague, and ratings for ease of application and removal. Free-text comments were recorded against several items.

Cost and resource analysis

A cost model was created in collaboration with Flen Health, comparing the four weeks preceding implementation with the four weeks following it. Twelve wounds were included; one case involving peri-wound moisture-associated skin damage was excluded because its management pathway differed from the other wound types included in the evaluation, making direct comparison of treatment costs inappropriate.

Product costs were taken from Trust purchasing data at the time of the evaluation. Healthcare professional costs were derived from the NICE resource impact template for topical antimicrobial dressings, using 2024/25 non-London Agenda for Change mid-points (NICE, 2025). Each dressing change was allocated 30 minutes of clinician time, which covered wound assessment, dressing removal, wound cleansing, dressing application and documentation. Enzyme alginogel use was

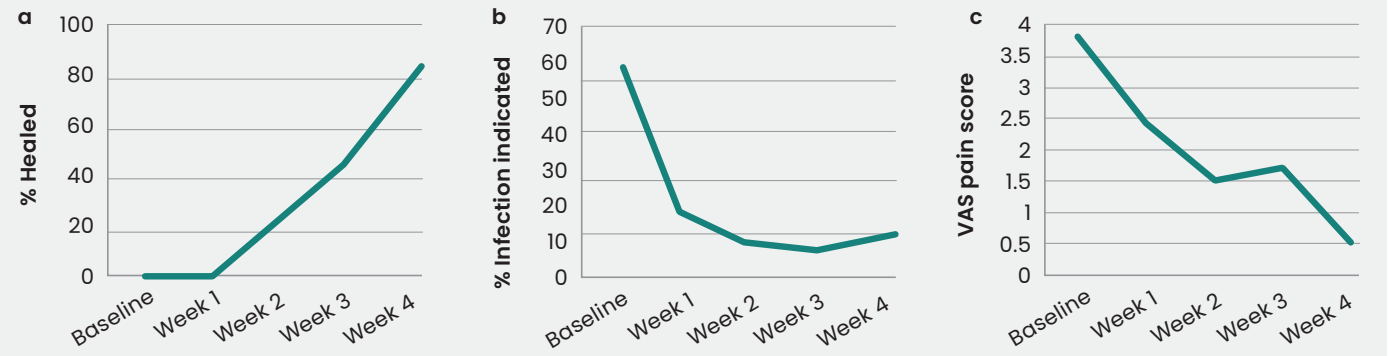

Figure 1

estimated from wound surface area or volume at a cost of £0.201 per cm².
Because patient numbers fell across the evaluation as wounds healed, average cost per patient was used as the primary comparator. Full methodology and assumptions are available from the authors.

Results

Clinical outcomes

Healing progressed steadily across the evaluation period **[Figure 1a]**. By week four, 11 of the 13 wounds (85%) had fully epithelialised. One case of peri-wound moisture-associated skin damage was analysed separately because its management pathway differed from the wound-bed cases included in the evaluation. Among the 12 wound-bed cases, 11 (92%) had healed; the twelfth had progressed to full granulation but had not yet epithelialised at week four. The peri-wound moisture-associated skin damage case did not close during the evaluation period and is reported separately in the discussion. Healing was achieved in a cohort in which many wounds (62%) had been present for 12 weeks or longer.

Of the 13 wounds, 11 had been managed with antimicrobial or advanced therapies prior to the change in approach, including antimicrobial dressings in nine cases and negative pressure wound therapy in five, without achieving progression.

Indicators of bioburden or local infection reduced markedly **[Figure 1b]**. Eight wounds (62%) demonstrated recorded infection indicators at baseline. By week four, no wound-bed case demonstrated ongoing indicators, representing complete resolution within this group. The only wound with persistent indicators at week four was the peri-wound moisture-associated skin damage case, discussed separately below.

Mean VAS pain scores fell from 3.8 at baseline to 0.5 by week four **[Figure 1c]**. Reduction was evident from the first week of treatment in most cases, and 11 of 13 wounds recorded a pain score of zero at week four.

Exudate levels stabilised over the same period. At baseline, eight wounds (62%) were recorded as low exudate and five (38%) as moderate. By week four no wound recorded moderate exudate; 12 wounds recorded no exudate and one recorded low exudate. Mean wound surface area also reduced across the cohort, from 12.0cm² to 4.4cm² among wounds included in the cost analysis.

Patient and clinician experience

Structured review data were available for 10 of the 13 wounds. Nine patients (90%) reported no pain or discomfort during or after dressing changes. Seven (70%) reported a reduction in wound-related stress, including reduced fear of dressing changes and reduced concern about odour and pain. Nine (90%) rated treatment as much more effective than their previous management, with the remaining patient rating it slightly more effective.

Clinician-reported outcomes were consistently positive. Primary, secondary and tertiary treatment aims were recorded as met or exceeded in every reviewed case, including the secondary aim of preventing biofilm formation, which had been set for all wounds at the outset. All reviewing clinicians said they would recommend the product to a colleague, and mean ratings for both ease of application and ease of removal were 10 out of 10 (100%).

Quality of life scores were recorded at both baseline and review. Among the 10 wounds with review data, mean scores improved (fell) from 42.7 to 18.1.

Cost and resource use

Cost and resource outcomes are summarised in **Table 3** and **Figure 2**.

Taking primary dressings, secondary and auxiliary products and healthcare professional time together, the average total cost burden fell from £167.41 to £56.30 per patient per week following implementation, a reduction of £111.11 or 66%.

Figure 1. Clinical outcomes across the evaluation period (n=13). (a) cumulative percentage of wounds healed; (b) percentage of wounds with recorded infection indicators; (c) Mean VAS pain score. The apparent increase at week four in (b) reflects the single peri-wound moisture-associated skin damage case, which remained in the denominator; no wound-bed case had ongoing indicators at week four.

Table 3. Cost and resource use before and after pathway implementation (n=12)
Per-patient averages. Pre-change = weeks -4 to -1; post-change = week of service change to week 4. The peri-wound moisture-associated skin damage case is excluded.

Cost outcomes (per patient, per week)			
Measure	**Pre-change**	**Post-change**	**Difference**
Primary dressing cost	£94.97	£4.21	-£90.76
Secondary dressing and auxiliary product cost	£19.66	£20.98	+£1.32
Healthcare professional cost	£52.78	£31.11	-£21.67
Total cost burden	**£167.41**	**£56.30**	**-£111.11 (-66%)**

Resource and clinical outcomes (time, material and wound area)			
Measure	**Pre-change**	**Post-change**	**Difference**
Healthcare professional time	1.00 hours	0.67 hours	-0.33 hours (-33%)
Unnecessary primary dressing waste	49.6cm²	0cm²	-49.6cm²
Released shared-care value	£0.00	£17.75	+£17.75
Mean wound surface area	12.0cm²	4.4cm²	-7.6cm²

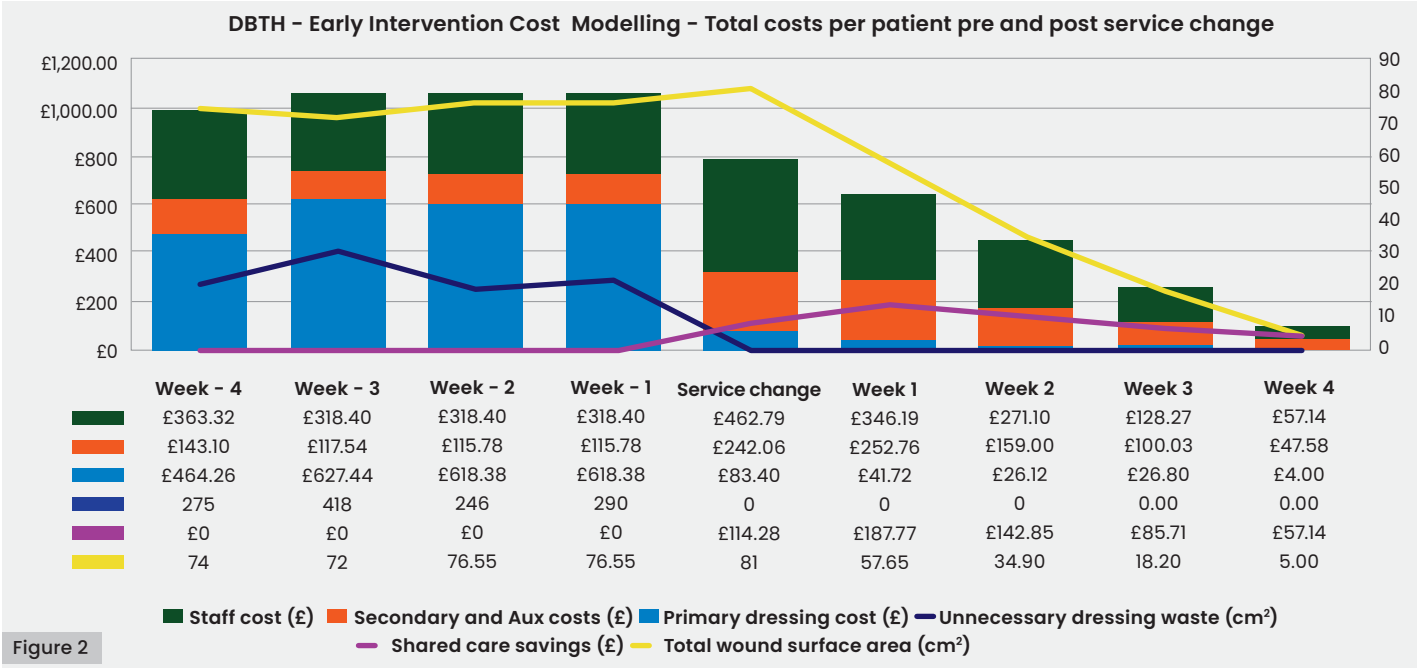

Figure 2

Figure 2. Total wound care costs per week across the evaluation period, four weeks before and after implementation (n=12). Values are totals across all patients contributing data in each week; patient numbers fall across follow-up as wounds heal.

Average primary dressing costs reduced by £90.76 per patient per week, largely reflecting a move away from negative pressure wound therapy following implementation. Average secondary dressing and auxiliary product costs increased slightly, by £1.32 per patient per week, an increase substantially outweighed by the reduction in primary dressing cost.

Average healthcare professional costs reduced by £21.67 per patient per week. Clinician time reduced from 1.00 to 0.67 hours per patient per week, a saving of approximately 20 minutes or 33%. This reflected a move towards a simpler dressing regimen, which created greater opportunity for supported self-care and shared care where clinically appropriate, so that fewer dressing changes required direct clinician involvement. The value

of care delivered through these arrangements rose from zero to £17.75 per patient per week.

The model also demonstrated the elimination of measurable unused primary dressing waste following implementation, from an average of 49.6cm² per patient per week to none. This was attributable to the use of a gel as the primary dressing, which is applied to the wound directly rather than cut to size, so that no unused material is discarded.

Discussion

The findings suggest that intervening at the first recognised signs of stalled healing, rather than waiting for overt clinical deterioration, was associated with rapid and consistent improvement. Pain reduced within the first week in most cases, infection indicators resolved completely among wound-bed cases, and the majority of wounds healed within four weeks despite having previously failed to progress. That these outcomes were achieved without recourse to systemic antimicrobials is relevant to antimicrobial stewardship: a topical, non-antibiotic intervention applied early appears to have interrupted progression along the infection continuum at a point where escalation might otherwise have been considered incurring a potential rise in clinical resource and cost. This is consistent with the principle that the continuum is most usefully understood as a prompt to act early rather than a description of inevitable decline (IWII, 2022).

The service-level findings are equally relevant. Reduced clinician time per patient is easily read as an abstract efficiency, but its practical meaning is capacity. Within this evaluation, every three patients managed under the revised pathway released approximately one hour of clinician time, equivalent to two additional 30-minute dressing appointments. Across the 12 wounds included in the cost analysis, this amounted to approximately four hours of released capacity, or eight further appointments that could be redirected to other patients requiring wound care. For a service managing a finite caseload, this is the difference between absorbing new referrals and deferring them. It should be emphasised that this represents clinical capacity released rather than a direct cash saving; the value is realised in improved patient flow and reduced waiting rather than in a reduced pay bill. The mechanism matters too. Supported self-care had been recorded as an explicit treatment aim in five cases at the outset, indicating that the shift in care delivery was an intended outcome of the approach rather than an incidental consequence. Capacity was released not by working faster but by simplifying the regimen sufficiently that patients and carers could safely take on a proportion of dressing changes themselves.

Several limitations should be noted. This was a small, single-site evaluation without a control or comparator group, so improvement cannot be attributed to the intervention alone, and the possibility that wounds would have progressed with any change in management cannot be excluded. Follow-up was limited to four weeks and recurrence was not assessed. Experience data were available for 10 of 13 wounds. The cost model relies on local product pricing, national mid-point staff rates and a stated set of assumptions, including a fixed 30 minutes of clinician time per dressing change, and would need to be recalculated before the findings were applied elsewhere. Healing was inferred where a wound no longer appeared in the following week of data. As a service evaluation rather than a research study, data were collected as part of routine care and were not independently verified.

One wound is reported separately. This patient was treated for peri-wound moisture-associated skin damage rather than wound-bed infection, and was excluded from the cost analysis because its management pathway differed from the wound bed cases. Clinically, the enzyme alginogel performed better than previous regimens for management of the surrounding skin and pain scores reduced during treatment. Persistent indicators of delayed healing in this case reflect underlying vascular compromise rather than treatment failure, and the case is retained in the clinical results in the interest of reporting the full cohort.

Conclusion

Introducing a multimodal enzyme alginogel (Flaminal®, Flen Health) at the earliest recognised signs of biofilm and/or infection, or stalled healing was associated with high rates of healing, complete resolution of infection indicators among wound-bed cases, and marked reductions in pain, in a cohort of complex wounds that had previously failed to progress. Alongside these clinical outcomes, the revised pathway reduced dressing costs, eliminated measurable primary dressing waste and released clinician time that could be redirected to other patients. The approach proved acceptable to both patients and clinicians and was deliverable within existing care models, including through supported self-care. Findings from this single-site evaluation support earlier intervention as a practical contribution to antimicrobial stewardship, and warrant evaluation in larger and more diverse cohorts.

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