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Early Surgical Escalation and Structured Multidisciplinary Pathways Improve Limb-Salvage Outcomes in Necrotizing Fasciitis: A Two-Cycle Quality Improvement Project

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Learning Point of the Article:

Structured early escalation and multidisciplinary pathways can shorten surgical decision-making and improve limb-salvage outcomes in necrotizing fasciitis.

Abstract

Introduction: Necrotizing fasciitis (NF) is a rapidly progressive, life-threatening soft-tissue infection characterized by extensive fascial necrosis and systemic toxicity. Reported mortality ranges from 20% to 40%, driven largely by diagnostic delay. Orthopedic units carry a disproportionate burden, particularly for lower-limb disease. This two-cycle quality improvement project (QIP) examined whether structured diagnostic pathways and early multidisciplinary escalation could reduce time to surgery and improve limb-salvage outcomes.

Case Series: Twenty-seven patients with confirmed or suspected NF were managed across two sequential audit cycles at a tertiary orthopedic center (Cycle 1, n = 14; Cycle 2, n = 13). Mean age was 52.1 ± 11.3 years; 80% had lower-limb involvement, and 70% had diabetes mellitus. Following QIP implementation, median time to surgical decision fell from 11.5 ± 3.2 to 6.8 ± 2.1 hours (P = 0.002). Recovery rates rose from 14.3% to 84.6% (P < 0.001) and major amputation rates declined from 35.7% to 15.4% (P = 0.04). Documentation of Laboratory Risk Indicator for Necrotizing Fasciitis scores and finger-sweep testing improved significantly. In-hospital mortality remained comparable (21.4% vs. 23.1%).

Conclusion: A structured, protocol-driven approach to NF management – encompassing mandatory diagnostic documentation, early senior involvement, and multidisciplinary team activation – substantially improves surgical timeliness and limb-salvage rates. Mortality reduction may require parallel optimization of perioperative sepsis management and critical care pathways.

Keywords: Necrotizing fasciitis, soft-tissue infection, quality improvement, LRINEC score, limb salvage, orthopedics.

Introduction

Necrotizing fasciitis (NF) is a rare but fulminant infection of the deep soft tissues that progresses rapidly along fascial planes, causing widespread necrosis, systemic sepsis, and multiorgan failure. Published mortality rates range from 20% to 40%, with higher figures consistently associated with diagnostic delay, inadequate initial debridement, and failure to involve senior decision-makers at the point of care [1]. Despite its severity, the early clinical presentation of NF is frequently indistinguishable from that of non-necrotizing cellulitis, and no single diagnostic test carries sufficient sensitivity to exclude the diagnosis confidently [2].

Orthopedic units bear particular responsibility for managing NF, since the majority of cases involve the lower extremity, where musculoskeletal involvement and the proximity of fascial compartments amplify the risk of limb loss [3]. The Laboratory

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Risk Indicator for Necrotizing Fasciitis (LRINEC) score provides a structured hematological screen. It remains the most widely validated bedside risk-stratification tool for distinguishing NF from other soft-tissue infections. However, its sensitivity for early disease is imperfect, and it should not be used in isolation [4]. Adjunctive bedside tools – most notably the finger-sweep test – and cross-sectional imaging with computed tomography (CT) contribute meaningful diagnostic information, particularly in atypical presentations [5].

Early surgical debridement is the single most consistently reported determinant of survival and limb salvage in NF, yet translating this evidence into consistent practice remains difficult in the emergency setting, where diagnostic uncertainty and variable escalation pathways often delay operative intervention [6,7]. Formalized quality improvement (QI) frameworks have increasingly been applied to surgical emergency pathways to reduce variation, accelerate decision-making, and improve documentation. Still, their application to NF care specifically remains limited [8,9].

The rationale for this study arises directly from this gap: while the association between surgical delay and poor outcome in NF is well established, little evidence exists on whether a structured, protocol-driven diagnostic and escalation pathway can measurably shorten that delay within a routine orthopedic service, rather than in a specialist or research setting [10,11]. A locally-led, protocol-based QIP therefore offered a pragmatic way to test this within existing service constraints, using a unit's own baseline practice as the comparator rather than an external control.

The objectives of this study were therefore twofold: first, to determine whether implementation of a structured diagnostic checklist, mandatory LRINEC and finger-sweep documentation, and early multidisciplinary team (MDT) activation reduced the time from presentation to surgical decision in patients with suspected or confirmed NF; and second, to evaluate the impact of this pathway on limb-salvage and mortality outcomes, comparing a baseline audit cycle against a second cycle following intervention.

Materials and Methods

Study design and setting

This was a two-cycle, retrospective, single-center QI project (QIP), structured as a before-and-after comparison of a consecutive case series rather than a randomized or blinded trial. It was conducted at a tertiary orthopedic center in Newport, United Kingdom, between June 2022 and October 2024. The unit manages the full spectrum of lower-limb NF and acts as a regional referral center for complex soft-tissue infections. Cycle 1 (June 2022–March 2023) established baseline practice, and Cycle 2 (April 2023–October 2024) assessed the impact of structured interventions. All patients were identified through electronic health records and specialist referral logs. The study was conducted under the auspices of institutional service evaluation and did not require formal ethics committee review; all data were anonymized before analysis.

Sample size

No formal a priori power calculation was performed, as this project was designed as a QI audit of consecutive, naturally occurring NF presentations rather than a hypothesis-driven comparative study with a pre-specified effect size. Sample size in each cycle was therefore determined pragmatically by the total number of patients meeting inclusion criteria within each cycle's fixed data-collection window (9 and 8 months respectively), giving 14 patients in Cycle 1 and 13 in Cycle 2. This is acknowledged as a limitation for the secondary outcomes in the Discussion, where the modest sample size limits statistical power to detect smaller effects.

Patient identification and data extraction

All patients aged ≥18 years admitted under orthopedic care with a confirmed or clinically suspected diagnosis of NF during the study period were included. Confirmation required either intraoperative findings consistent with NF (gray necrotic fascia, lack of bleeding, tissue plane dissection without resistance) or microbiological/histopathological evidence. Cases managed conservatively without operative exploration were included if the clinical diagnosis was substantiated by imaging and clinical progression.

Data extraction encompassed: patient demographics and comorbidities; anatomical site of infection; causative organisms and antibiotic sensitivities; LRINEC score at presentation; performance and outcome of finger-sweep test; CT imaging results; time from initial presentation to first senior clinical review; time from presentation to operative decision; type and number of surgical procedures; length of hospital stay; and final clinical outcome (recovery, major amputation, or in-hospital death).

Cycle 1: Baseline assessment

Cycle 1 (June 2022–March 2023) was conducted prior to any structured intervention and reflected existing departmental practice for suspected NF. No diagnostic checklist, mandatory documentation standard, or fixed escalation timeframe was in place; LRINEC scoring, finger-sweep testing, CT imaging, and

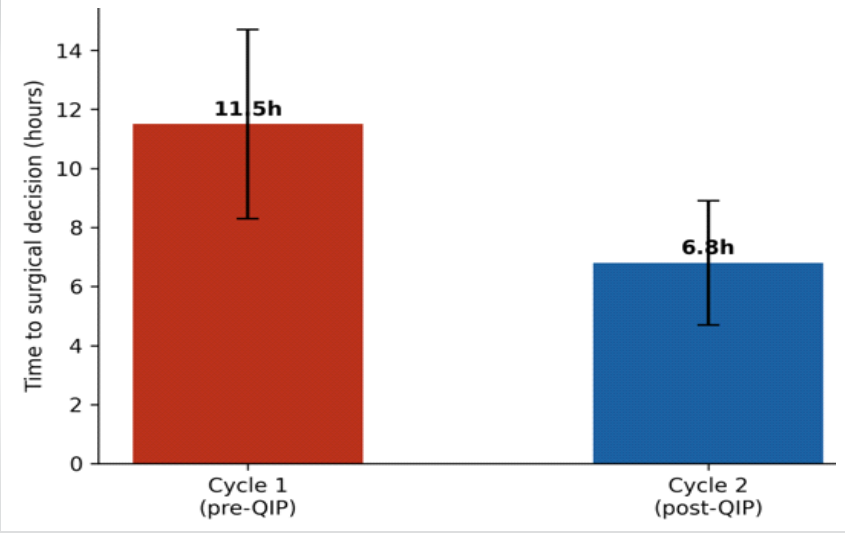


Figure 1: Mean time to surgical decision (h) in Cycle 1 (pre-quality improvement project [QIP]) versus Cycle 2 (post-QIP). Error bars represent±standard deviation. The 41% reduction was statistically significant (P=0.002).

MDT referral were performed at individual clinician discretion rather than as protocolized steps. Data on time to senior review, time to surgical decision, diagnostic test use, and clinical outcomes were collected retrospectively for this cycle to establish a baseline against which the Cycle 2 intervention bundle could be measured. Findings from Cycle 1 – in particular the low rates of LRINEC and finger-sweep documentation and the long interval to surgical decision – were reviewed by the multidisciplinary group and directly informed the design of the structured intervention bundle described below.

QI interventions (Cycle 2)

Following completion of Cycle 1, a series of targeted interventions were developed collaboratively with orthopedic, emergency medicine, infectious diseases, microbiology, and plastic surgery teams:

1. Implementation of a structured NF diagnostic checklist at the point of initial senior review
2. Mandatory documentation of LRINEC score within two hours of presentation
3. Standardized recording of finger-sweep test performance and result
4. Mandatory CT documentation with confirmation of whether gas, fascial edema, or soft-tissue emphysema was identified
5. Direct escalation to consultant orthopedic surgeon within 4 h of presentation if NF was suspected
6. Compulsory early MDT activation including infectious diseases, microbiology, and plastic surgery
7. Interactive education sessions for emergency department nursing and junior medical staff on NF recognition and escalation triggers.

Statistical analysis

Descriptive statistics were used to summarize patient demographics and baseline characteristics. Categorical variables were compared between cycles using Chi-squared or Fisher's exact tests, as appropriate. Continuous variables were assessed using an independent samples t-test or Mann–Whitney U test depending on data distribution. Statistical significance was defined as $P < 0.05$. All analyses were performed using Statistical Package for the Social Sciences Statistics version 27.0 (IBM Corp., Armonk, NY, USA). Results are presented with 95% confidence intervals where applicable.

Results

Patient demographics and baseline characteristics

A total of 27 patients were included across both cycles (Cycle 1: n = 14; Cycle 2: n = 13). The mean age was 52.1 ± 11.3 years, with a slight male predominance (63%). Diabetes mellitus was the most prevalent comorbidity, present in 70% of cases. Lower-limb infection predominated in both cycles (78.6% and 84.6%, respectively), and polymicrobial infection was identified in the majority of cultured specimens. Baseline characteristics were

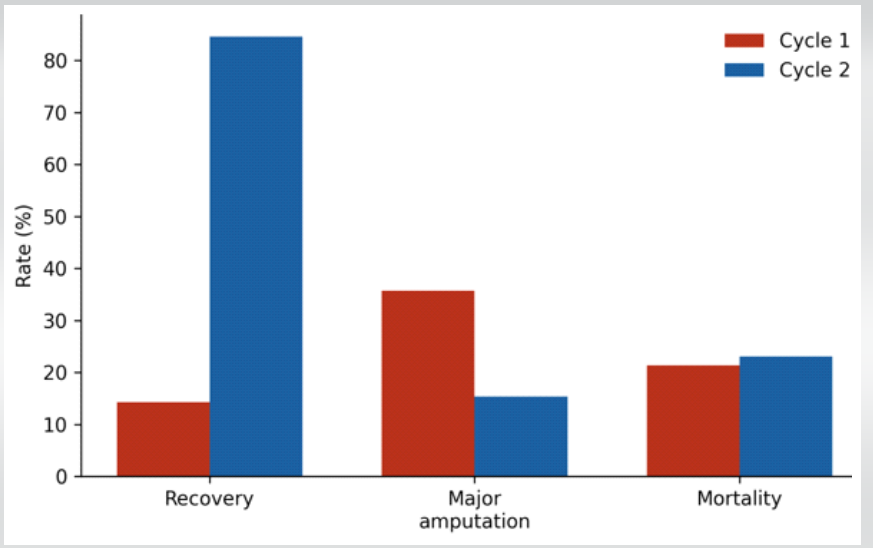


Figure 2: Clinical outcome rates (%) in Cycle 1 versus Cycle 2. Recovery rate improved significantly (P<0.001) and amputation rate declined significantly (P=0.04). Mortality remained comparable between cycles (P=0.91).

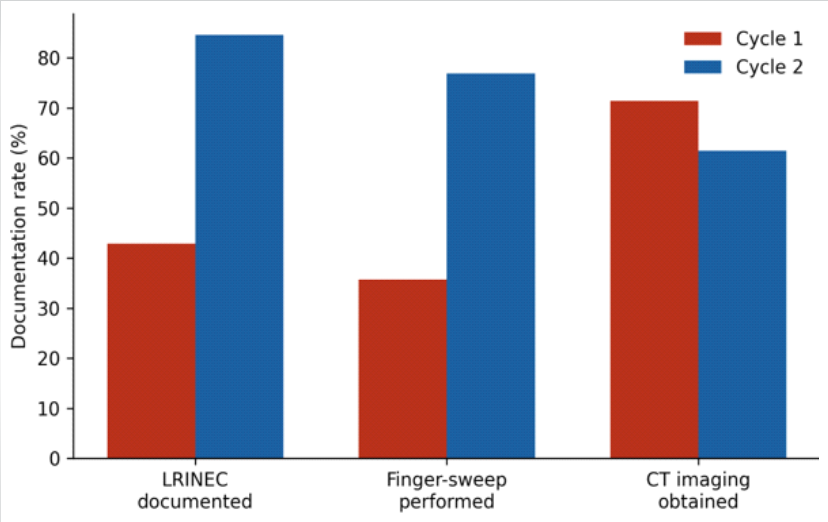


Figure 3: Diagnostic tool documentation rates (%) in Cycle 1 versus Cycle 2. Laboratory risk indicator for necrotizing fasciitis score documentation (P=0.01) and finger-sweep test performance (P=0.02) improved significantly. Computed tomography imaging documentation rate did not significantly differ (P=0.57).

comparable between cycles, with no statistically significant intergroup differences (Table 1).

Diagnostic timeliness and documentation

Following QIP implementation, significant improvements were observed across all documentation metrics (Table 2). LRINEC score utilization nearly doubled, from 42.9% in Cycle 1 to 84.6% in Cycle 2 (P = 0.01). Finger-sweep test performance rose from 35.7% to 76.9% (P = 0.02). Time to first senior clinical review fell from a mean of 4.2 ± 1.8 h to 2.1 ± 0.9 h (P = 0.003). Most strikingly, the mean time from presentation to operative decision decreased from 11.5 ± 3.2 h in Cycle 1 to 6.8 ± 2.1 h in Cycle 2 (P = 0.002), representing a 41% reduction. MDT involvement increased from 50.0% to 92.3% (P = 0.01). CT imaging use appeared marginally lower in Cycle 2; however, this reflected documentation inconsistency rather than a true reduction in practice.

Clinical outcomes

Cycle 2 demonstrated marked improvements in limb-salvage outcomes (Table 3). Recovery rates – defined as discharge home with functional limb preservation – rose from 14.3% in Cycle 1 to 84.6% in Cycle 2 (P < 0.001). Major limb amputation rates fell from 35.7% to 15.4% (P = 0.04). Limb-salvage debridement rates trended upward (42.9% vs. 61.5%; P = 0.15), though this did not reach statistical significance, likely reflecting the modest sample size.

In-hospital mortality remained comparable across both cycles (21.4% vs. 23.1%; P = 0.91), consistent with the observed persistence of fulminant disease in a subset of patients despite improved surgical timeliness. Secondary outcomes including intensive care admission rate, median number of debridement procedures, and length of hospital stay showed numerical improvement in Cycle 2, though none reached statistical significance (Figs. 1, 2, 3).

Discussion

This two-cycle QIP demonstrates that structured, protocol-driven interventions can substantially reduce the time from presentation to operative decision and significantly improve limb-salvage rates in orthopedic NF management. The 41% reduction in time to surgical decision is clinically meaningful, given that necrotizing infection can progress within hours [1], that organized systems of care are considered central to its management [2], and that surgical delay is consistently associated with higher mortality [3–5]. The Infectious Diseases Society of America guidelines call for urgent surgical inspection and debridement when a necrotizing infection is suspected [6]; however, most published series reporting favorable outcomes document surgical exploration considerably earlier [7–9]. Our data support the premise that reducing this interval – even within a service where care was already relatively prompt – yields tangible benefits in terms of limb salvage.

Table 1: Baseline patient demographics and microbiology by cycle

Characteristic	Cycle 1 (*n*=14)	Cycle 2 (*n*=13)	*P*-value
Age, years (mean±SD)	51.4 ± 12.1	52.9 ± 10.6	0.72
Male sex, *n* (%)	9 (64.3)	8 (61.5)	0.87
Diabetes mellitus, *n* (%)	10 (71.4)	9 (69.2)	0.89
Immunosuppression,*n* (%)	4 (28.6)	3 (23.1)	0.71
Peripheral vascular disease, *n* (%)	3 (21.4)	2 (15.4)	0.66
Obesity (BMI >30), *n* (%)	5 (35.7)	4 (30.8)	0.76
Lower limb, *n* (%)	11 (78.6)	11 (84.6)	0.66
Upper limb, *n* (%)	2 (14.3)	1 (7.7)	0.55
Perineum/trunk,*n* (%)	1 (7.1)	1 (7.7)	0.95
Polymicrobial infection, *n* (%)	8 (57.1)	7 (53.8)	0.84
Group A Streptococcus, *n* (%)	4 (28.6)	4 (30.8)	0.89
Culture negative,*n* (%)	2 (14.3)	2 (15.4)	0.93

Groups were compared using Chi-squared or Fisher's exact test for categorical variables and an independent samples t-test for continuous variables. No significant differences between cycles. SD: Standard deviation, BMI: Body mass index

Table 2: Diagnostic metrics and timeliness by audit cycle

Diagnostic metric	Cycle 1 (n=14)	Cycle 2 (n=13)	P-value
LRINEC score documented,n (%)	6 (42.9)	11 (84.6)	0.01*
LRINEC ≥6 (high risk),n (%)	4 (66.7)	9 (81.8)	0.41
LRINEC mean score (±SD)	5.8±2.3	7.2±1.9	0.09
Finger-sweep test performed, n (%)	5 (35.7)	10 (76.9)	0.02*
Positive finger-sweep, n (%)	4 (80.0)	9 (90.0)	0.54
CT imaging obtained,n (%)	10 (71.4)	8 (61.5)	0.57
Gas on CT, n (%)	6 (60.0)	5 (62.5)	0.91
Time to senior review, hours (mean±SD)	4.2±1.8	2.1±0.9	0.003*
Time to surgical decision, hours (mean±SD)	11.5±3.2	6.8±2.1	0.002*
MDT involvement, n (%)	7 (50.0)	12 (92.3)	0.01*

***Statistically significant (P<0.05). LRINEC: Laboratory risk indicator for necrotizing fasciitis, CT: Computed tomography, SD: Standard deviation, MDT: Multidisciplinary team**

The dramatic improvement in recovery rates (14.3–84.6%) warrants careful interpretation. Cycle 1 data likely captured a period of suboptimal practice, characterized by diagnostic hesitancy, delayed escalation, and inconsistent documentation. Diagnostic hesitancy is well described in necrotizing soft-tissue infection, as the early features are often difficult to separate from cellulitis [10]. The QIP interventions addressed these deficiencies directly and systematically. Similar patterns have been reported in other QI studies of NF pathways, where multidisciplinary activation and mandatory documentation of diagnostic tools produced step-change improvements in process metrics and secondary clinical outcomes [11,12]. Published guidance likewise favors a multidisciplinary, multiparametric assessment over reliance on any single sign or test [13,14]. The reduction in major amputation from 35.7% to 15.4% aligns with data suggesting that earlier fasciotomy and debridement reduce the extent of irreversible tissue loss and preserve viable limb segments [15,16]. Baseline severity of illness also influences survival and limb outcomes, and the two cycles should be compared with that in mind [17].

Improvements in LRINEC documentation (42.9–84.6%) and finger-sweep test performance (35.7–76.9%) reflect the utility of formalized checklists in emergency surgical settings. The LRINEC score, originally derived and validated by Wong et al. as a six-parameter hematological scoring system to distinguish NF from severe cellulitis and other soft-tissue infections [18], remains the most widely adopted bedside risk-stratification tool in this context. However, its predictive accuracy remains contested, with reported sensitivities ranging from 68 to 80% across different populations [19,20], and it has also been examined in a tropical tertiary referral population [21]. Newer early warning models have been proposed to address these limitations [22]. Its structured use nonetheless appears to enhance clinical vigilance and reduce the risk of missed early cases. The finger-sweep test, while highly specific when positive, requires senior operator experience for reliable interpretation [23]. The increased documentation rates achieved here suggest that education and protocol mandation can overcome the barriers to its uptake in routine practice. Cross-sectional imaging may assist when the diagnosis is uncertain. MRI has been reported to help separate necrotizing fasciitis from cellulitis [24], CT has been used to define deep infection, although the reported experience is largely in head and neck disease [25], and combining clinical and radiological assessment has been reported to improve diagnostic accuracy [26]. Imaging should not delay surgical exploration when clinical suspicion is high.

Unchanged mortality across cycles (21.4% vs. 23.1%) was not unexpected, and mirrors published literature showing that NF mortality is driven predominantly by host factors – including severity of sepsis at presentation, comorbid immunosuppression, and the virulence of infecting organisms – rather than by modifiable process variables alone [27,28]. Our cohort carried a high burden of diabetes mellitus (70%), a recognized independent predictor of NF mortality [29]. It is plausible that further reductions in mortality will require parallel optimization of perioperative resuscitation, early sepsis

Table 3: Clinical outcomes by audit cycle

Outcome	Cycle 1 (n=14)	Cycle 2 (n=13)	P-value
In-hospital mortality,n (%)	3 (21.4)	3 (23.1)	0.91
Recovery (discharged home),n (%)	2 (14.3)	11 (84.6)	<0.001*
Major limb amputation,n (%)	5 (35.7)	2 (15.4)	0.04*
Limb-salvage debridement,n (%)	6 (42.9)	8 (61.5)	0.15
Intensive care admission,n (%)	8 (57.1)	7 (53.8)	0.84
Total debridement procedures (median)	2.5 (1–5)	2.0 (1–4)	0.48
Hospital length of stay, days (mean±SD)	28.4±11.6	22.1±9.3	0.08
Wound closure/skin graft,n (%)	5 (35.7)	8 (61.5)	0.15
Re-operation rate, n (%)	4 (28.6)	3 (23.1)	0.72
Discharge to rehabilitation, n (%)	4 (28.6)	8 (61.5)	0.07

***Statistically significant (P<0.05). Values represent n (%) unless otherwise stated**

bundle adherence, and post-operative critical care pathways – elements that lie beyond the scope of the current QIP but represent clear targets for future audit cycles.

This study has limitations inherent to its retrospective QIP design and modest sample size, which limit statistical power for secondary outcomes and preclude definitive causal inference; as noted above, no a priori sample size calculation was performed, and the cohort size instead reflects consecutive real-world caseload within each fixed audit window. The two cycles were not contemporaneous, introducing the possibility of secular trends in NF management affecting outcomes. Compliance with individual QIP interventions was not formally tracked, and the relative contribution of each component cannot be disaggregated from the bundle effect. Future work should prospectively evaluate individual intervention components, incorporate patient-reported outcome measures, and include longer follow-up to assess functional recovery beyond the acute admission.

Conclusion

NF demands urgent, coordinated surgical care. This two-cycle QIP demonstrates that the introduction of structured diagnostic pathways, mandatory clinical documentation, and early multidisciplinary escalation can produce clinically significant reductions in operative delay and major amputation rates within an orthopedic service. These improvements are achievable with low-cost, high-impact interventions targeting process compliance rather than infrastructure. Mortality reduction will likely require additional focus on perioperative sepsis management and critical care integration. Continued audit cycles and prospective evaluation of individual pathway components are recommended to sustain and extend these gains.

Clinical Message

Early recognition, prompt senior surgical escalation, and structured multidisciplinary management of NF can substantially reduce delays to operative decision-making and may improve limb-salvage outcomes. A simple protocol incorporating mandatory diagnostic assessment, early consultant involvement, and MDT activation can be implemented within routine orthopedic practice.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

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