ORIGINAL ARTICLE

Circular External Fixator Removal in the Outpatient Clinic Using Regional Anaesthesia: A Pilot Study of a Novel Approach

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Abstract

Introduction: External fixator (EF) devices are commonly used in the management of complex skeletal trauma, as well as in elective limb reconstruction surgery for the management of congenital and acquired pathology. The subsequent removal of an EF is commonly performed under general anaesthesia in an operating theatre. This practice is resource-intensive and limits the amount of time available for other surgical cases in the operating theatre. We aimed to assess the use of regional anaesthesia as an alternative method of analgesia to facilitate the EF removal in an outpatient setting.

Design and methods: This prospective case series evaluated the first 50 consecutive cases of EF removal in the outpatient clinic between 10/06/22 and 03/02/23. Regional anaesthesia using ultrasound-guided blockade of peripheral nerves was administered using 1% lidocaine due to its rapid onset and short half-life. Patients were assessed for additional analgesia requirements and then were asked to evaluate their experience and perceived pain using the visual analogue scale (VAS).

Results: Fifty patients were included in the study. The mean age was 46.8 years (range 21–85 years). About 54% of the patients were male patients ($N = 27$). Post-procedure, all patients indicated positive satisfaction ratings, each participant responded as either **'satisfied'** ($N = 6$), **'very satisfied'** ($N = 24$) or **'highly satisfied'** ($N = 20$). In addition, 90% of the participants reported that they would opt for this method of EF removal again in future. The VAS for pain immediately following completion of the procedure was low, with a mean score of 0.36 (range 0–4), where a score of 0 = 'No pain', and 10 = 'worst pain possible'. The median score was 0.

Conclusion: We present the first description of outpatient EF removal using regional anaesthesia, with a prospective case series of 50 fully conscious patients from whom the EF was removed. This novel technique is likely to be cost-effective, reproducible, and safe. This technique reduces the burden of EF removal from an operating list and also improves the patient's experience when compared with other forms of conscious sedation. By eliminating the use of Entonox and methoxyflurane for sedation and analgesia, this technique also demonstrates a method of improving environmental sustainability.

Keywords: External fixator, Frame removal, Limb reconstruction, Relative stability, Regional anaesthesia, Ultrasound-guided nerve blocks.

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Introduction

In trauma and orthopaedic surgery, external fixator (EF) devices are commonly used to treat fractures, in addition to their use in the management of both acquired and congenital pathology across the spectrum of limb reconstruction surgery.[1] In their various forms, EFs can gradually correct complex three-dimensional deformities, provide stability to bone and soft tissues in high-energy trauma, and provide a good solution in situations where internal fixation has failed or is unsuitable.[2]

After the completion of EF treatment, removal of the EF often requires general anaesthesia (GA) in an operating theatre. Less commonly, EFs are removed under sedation in an outpatient setting using nitrous oxide with oxygen (Entonox), or more recently, methoxyflurane (Penthrox) inhalation. Prior to the SARS-CoV-2 pandemic, removal under GA was common in our unit; however, operating theatre availability is dramatically altered in 2023. Conscious sedation using Entonox had been used occasionally over many years for patients who would tolerate this and wished

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to avoid an additional GA for EF removal. More recently, Penthrox was used in our unit between 2020 and 2022 to facilitate EF removal in the outpatient clinic.[3] The authors found that a proportion of patients had a suboptimal experience due to inadequate pain control using this method of conscious sedation, and therefore in conjunction with the limb reconstruction multidisciplinary team and an anaesthetist working in our unit, we developed a pathway for EF removal using regional anaesthesia in the outpatient clinic.

Debuka et al. found that the average time (from sending the patient inside the operating room until sending the next patient) for EF removal in the operating theatre was 63 minutes, and that a two-session (8 hours) operating list costs £2266. Each EF removal performed in this way can be estimated at £297. However, this is likely to be a significant underestimate of the true cost-utility of the procedure.[3]

In addition to potential cost savings, EF removal in outpatient clinic would decrease the burden on trauma and elective theatre capacity as clinical teams work to tackle the backlog of patients waiting for surgery. EF removal using regional anaesthesia may additionally offer an improved patient experience and avoid potential complications associated with a GA. Reduced reliance on inhaled anaesthetic gases that have been proven to be harmful to the environment would also improve sustainability.[4]

We aimed to assess the use of regional anaesthesia as an alternative method of analgesia to facilitate the EF removal in an outpatient setting. Our main outcome measures were the patient's pain score, as measured with a visual analogue scale (VAS), and their satisfaction, measured using a Likert scale.

Design and Methods

A prospective case series of patients scheduled for EF removal in the outpatient clinic at a tertiary referral limb reconstruction service between 10/06/22 and 03/02/23 was identified for this pilot study. Patients were counselled prior to their clinic attendance and consented verbally for the removal of their EF using regional anaesthetic blockade. The study was registered with the hospital audit and quality improvement department, and approval was obtained. Engagement with the outpatient clinic nursing team allowed us to identify a suitable environment and ensure safe staffing levels. All patients with any type of EF were eligible for inclusion. Patient refusal to a peripheral nerve block, chronic pain, or a pre-procedural VAS score of >5 led to exclusion from the study.

On the day of the procedure, consent was re-confirmed and minimum standards of monitoring suggested by the Association of Anaesthetists were applied.[5] The procedures were performed in a standard clinic room and aseptic precautions were followed for the nerve block as well as for the removal of EFs (Fig. 1).

The EFs removed included fine wires and half-pins and were removed using a routine technique. Frame removal was primarily performed by our limb reconstruction specialist physiotherapists, with input from the surgical and specialist nursing team as required. Local anaesthetic toxicity risk was deemed to be low, as doses did not exceed 3 mg/kg; however a 'safety pack' including intralipid was always available in the outpatient department in the case of emergency.

Nerve blocks were administered by a Consultant Anaesthetist experienced in regional anaesthesia and administered as per the requirements of the type of EF. Popliteal and saphenous nerve blocks were used for tibial EF. Supraclavicular plexus block was used for humeral EF and one EF on the femur required blockade of the femoral nerve, lateral cutaneous nerve of the thigh and proximal sciatic nerve. All blocks were conducted using ultrasound (US) guidance and achieved with 1% lidocaine, volume titrated to the patient body weight. Lidocaine was chosen due to its rapid onset of action and short half-life. The block administered was primarily a sensory nerve block, and the effects of the block reliably begin to ease after a period of 60–90 minutes. In practice, this meant that once frame removal had been completed, dressings applied and immobilisation (usually in the form of plaster cast) provided, the effect of the blockade had worn off and the patient was ready to leave the outpatient department.

Fig. 1: Administration of regional nerve block under ultrasound guidance

During the procedure, the patient was observed for any signs of pain or discomfort. Since the patients were not under the influence of any kind of sedation, they were able to convey what and how they felt. They were also able to follow the instructions from the clinicians to remove the EF. Patients were shown a diagram of the VAS as shown in Figure 2 before and immediately following the procedure and were asked to report their pain.[6]

Patients were also asked to rate their overall satisfaction following the completion of the procedure using the following Likert scale:

'Highly dissatisfied', 'Very Dissatisfied', 'Dissatisfied', 'Satisfied', 'Very Satisfied', or 'Highly Satisfied'.

Patients were then asked whether they would undergo EF removal using regional anaesthesia in the outpatient clinic again in future, or would prefer it to be performed under GA. Any complications related to the block or the removal of EF, the requirement for additional analgesia and the need to abandon the procedure were also recorded.

Results

In total, 50 consecutive patients were included in this prospective feasibility study. No patients were excluded based on pre-procedural pain scores. However, three patients were excluded

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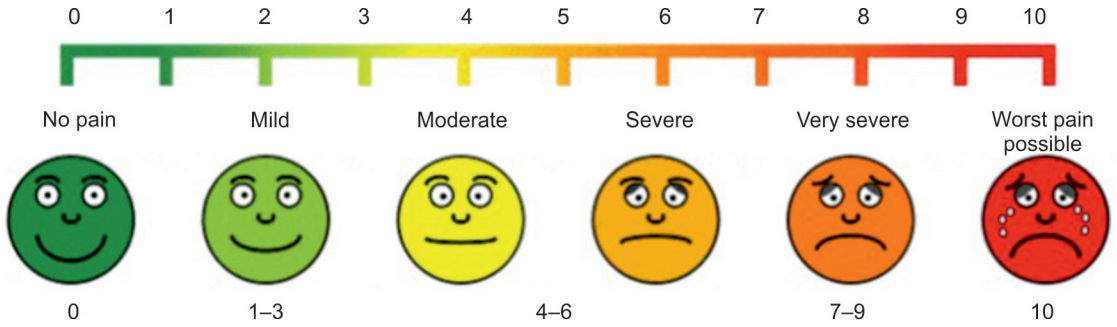

Fig. 2: Visual analogue scale (VAS) for perceived pain

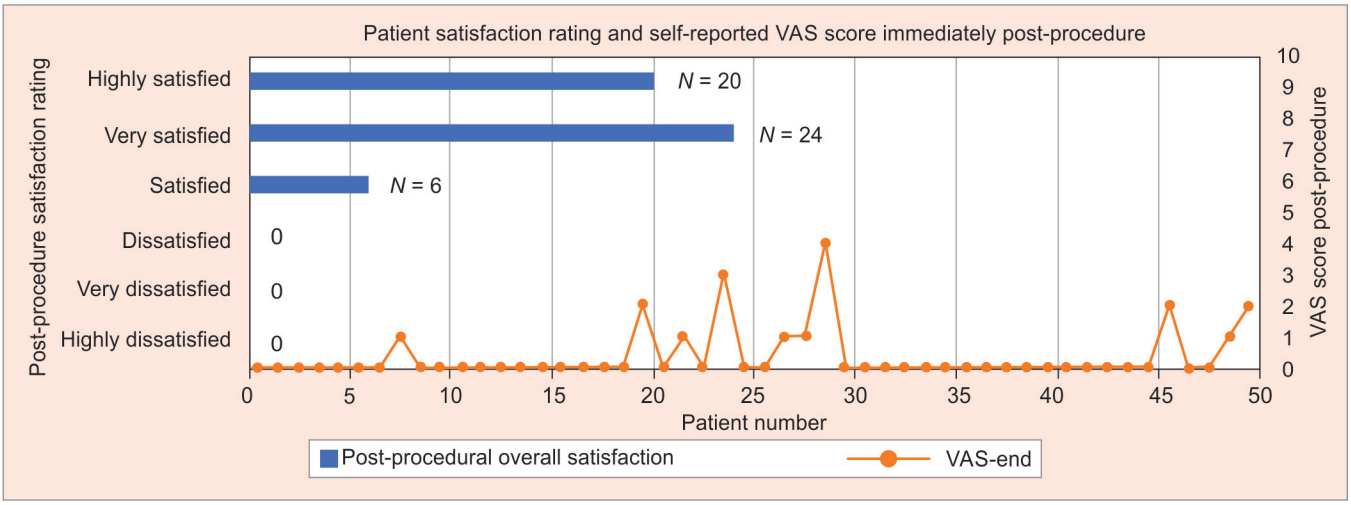

Fig. 3: Graph of patient overall satisfaction ratings and VAS scores

due to chronic pain or refusal to undergo a regional anaesthetic block in the clinic setting.

The mean age of participants was 46.8 years (range 21–85 years). About 54% were male patients (*N* = 27). The comorbid status of patients varied with documented American Society of Anaesthesiologists (ASA) grades between I and IV. The mean duration of the procedure was 43 minutes (range 20–78 minutes), calculated from the time the block had been administered.Of the 50 cases included, there were 47 cases of tibial EFs removed under popliteal sciatic and saphenous nerve blocks. Two cases of humeral EF removal were performed successfully, one of which was an ASA IV patient who did not want GA due to high risk from her comorbidities. A single femoral EF was removed using femoral, lateral cutaneous nerve of thigh, and sciatic nerve blockade.

Following the procedure, all patients indicated positive satisfaction ratings, with each participant responding as either **'satisfied'** (*N* = 6), **'very satisfied'** (*N* = 24) or **'highly satisfied'** (*N* = 20). Additionally, 90% of the patients reported that they would opt for this method of treatment in the future should it be required in their ongoing care. Five participants stated that they wished not to opt for this treatment method in future, and all gave a VAS-end score between 0 (no pain) and 2 (mild pain), and were 'satisfied' with their treatment. Reasons stated included a preference for a GA due to procedural anxiety and discomfort during the removal of proximal tibial half-pins and described as a 'pressure' rather than pain. One patient requested additional pain relief and received inhaled Penthrox (Fig. 3).

The VAS for pain immediately following the completion of the procedure was low with a mean score of 0.36 (range 0–4), where a score of 0 = 'No pain', and 10 = 'worst pain possible'. The median pain score and interquartile range were 0.

None of the patients were assessed as being agitated during the EF removal process. There were no complications recorded for the US-guided peripheral nerve block or removal of EFs. Two patients had previous exposure to Penthrox. One did not want to use inhaled gas for any subsequent procedure and the other said that she had experienced a 'thumping headache' for 2 days which did not respond to analgesia.

There was one patient who requested additional analgesia in the form of Entonox inhalation. This Entonox inhalation was used during saphenous nerve blockade and whilst removing a half-pin. There were no adverse complications during the EF removals. Two patients required subsequent GA to remove an 'olive' wire that had become stuck within the bone and could not be removed in clinic.

Discussion

This prospective feasibility study demonstrates that from the perspective of patient experience and pain control, this novel technique is a good option for EF removal. All patients at the very least were 'satisfied' with their care, with a majority of patients reporting they were either 'Very Satisfied' (48%) or 'Highly Satisfied' (40%). This is further supported by the mean VAS score of 0.36/10

indicating that the pain experienced lies between 'mild' and 'no pain' in this series.

In the current literature, there is much discussion regarding when the correct time is to remove an EF and how this might be predicted; however, there is little data regarding the environment or method for EF removal. In centres across the UK, the most common practice traditionally has been to remove EFs in theatre. When removed in the clinic, this is usually performed using Entonox as conscious sedation.[7] There has also been the successful use of Penthrox for the removal of EFs; however, sample sizes are small and patient tolerance is not well-documented. Gray Stephens et al. performed a review of 97 unique episodes of various orthopaedic trauma amongst a total of 89 patients where conscious sedation with Penthrox was used. Most of these constituted extremity fractures and dislocations; however, they did document its use in two cases of removal of EFs. They recorded a 'successful' outcome, in that the procedure was carried out to completion without complication. However, they did not collect any qualitative data to document patient perception of analgesic effectiveness or associated side effects.[8]

The use of inhalational anaesthetic agents for conscious sedation can give less reliable analgesic effects than regional anaesthesia and can produce unwanted side effects. Coffey et al. found that drug-related adverse events in a study of 298 patients occurred at a higher rate in patients treated with Penthrox compared with those given placebo in patients presenting to Emergency departments with minor trauma (36.2% vs 13.4%).[9] There have also been reported concerns of occupational exposure risk to healthcare providers regarding the delivery of inhalational anaesthetic agents.[10] These gases have also been shown to contribute to the greenhouse effect, which makes them a less sustainable solution.[11]

We have presented a prospective feasibility case series, and further work is needed to confirm these findings. However our results suggest that peripheral nerve blockade under US guidance in the outpatient clinic is likely to be safe and effective. Complications from peripheral nerve blocks are very rare; however, any team using this technique must be familiar with the potential issues that can arise and their management.[12]

There is a learning curve for this technique, with a requirement for an experienced anaesthetist who is confident with and efficient at regional anaesthesia to be available in the outpatient clinic. Clinical staff with experience in EF management and removal are also required. These clinicians need an adequate working environment with support from nursing staff in the outpatient clinic. Our specialist limb reconstruction physiotherapy team performed the majority of the EF removals which allowed the surgical team to simultaneously review other outpatients in the clinic. We noticed a reduction in the time required to remove the EF under regional blocks as compared with that under sedation using inhalational techniques. The highest number of EF removals during 1 day in the outpatient clinic was 11. We believe that this technique is transferable to other units.[13,14]

Inhalational anaesthetic agents are greenhouse gases with a negative environmental impact. The use of these gases also risks exposure to staff in a similar mechanism to passive smoking. Standard clinic rooms are not specifically ventilated and do not have scavenging for waste anaesthetic gases, and therefore, some gas will inevitably be inhaled by staff present in the room. It is difficult to quantify this exposure and the long-term implications are unknown.

Removal of EFs in the outpatient setting is likely to improve the patient journey and experience. This method saves patients two additional visits to the hospital, one for a preoperative assessment and another on the day of the surgery.

The authors acknowledge that there are several limitations to this pilot study, and further work will be needed in similar specialist units nationally to demonstrate that our good initial results are reproducible. We have not performed a formal cost analysis; however, the removal of EF in the outpatient setting is more cost-effective than doing so in the operating theatre. A multi-centre report from units that perform large numbers of EF removals would allow a robust analysis of cost-effectiveness including staffing costs. This could then potentially inform national guidance. Additionally, we acknowledge that our initial sample size of 50 patients may not identify all potential issues and complications that might be associated with this method. Therefore our unit will continue to collect data prospectively and report the results of a larger sample. It may also be beneficial to directly compare the removal under GA with other methods of conscious sedation.

Conclusion

To the best of our knowledge, our unit is the first to describe EF removal using regional anaesthesia in the outpatient setting. Our pilot study of this novel method of EF removal suggests that this method is safe and effective. It is likely that this technique represents a significant cost saving when compared with removal in an operating theatre and may also provide a better patient experience. The reduced use of inhalational anaesthetic gases is also likely to improve environmental sustainability.

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