CASE REPORT

Extraction of a Broken PRECICE Bone Transport System: A Case Report and Technique for Residual Limb Salvage

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Abstract

Aim: To describe a surgical technique for the safe removal of a broken non-cannulated PRECICE bone transport nail (NuVasive Specialized Orthopedics) without compromising limb reconstruction.

Background: The removal of broken non-cannulated intramedullary lengthening nails (IMLNs) is challenging. Few techniques have been described for the safe removal of these devices without compromising bone salvage.

Case description: A 42-year-old male presented for complex right tibia reconstruction following a type IIIB open tibia fracture with a 92-mm bone defect. The bone defect was initially managed with an all-internal bone transport nail system (PRECICE bone transport). At the 13-month follow-up, the patient presented with a broken lengthening nail, varus limb deformity, and nonunion at the docking site. The nail components were extracted sequentially, and a burr hole was created in the distal segment of the nail through the nonunion site to facilitate removal. The residual varus deformity and tibial shaft nonunion were managed with a hexapod frame.

Conclusion: The IMLN was successfully removed without compromising limb reconstruction. By sequentially removing the components of the nail and altering the distal portion of the implant through the nonunion site, safe removal of the implant without further bone loss was achieved.

Clinical significance: This report describes an efficient technique for the removal of broken non-cannulated IMLNs when extractors are not available.

Keywords: Bone defect, Case report, Hardware failure, Intramedullary lengthening nail, Reconstruction, Tibia.

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Background

Magnetic-controlled intramedullary bone-transport limb lengthening devices offer an accurate and predictable all-internal method for the management of critical bone defects. While the traditional management of large bone defects (>5 cm) with ring fixators has been successful, complications such as prolonged external fixation time, scarring, and pin-site infections can become problematic.[1] All-internal lengthening and reconstruction techniques are advantageous due to their ability to decrease, or eliminate, external fixation time and improve patient satisfaction.[2,3] Despite complex intrinsic mechanisms and low complication rates, intramedullary lengthening nails (IMLNs) are not immune to cyclical loading fatigue and can break within the medullary canal of long bones, necessitating surgical retrieval.[4,5] As IMLNs are not cannulated, extraction of broken nails can prove challenging.[6] In this report, a new technique for the removal of a broken PRECICE bone transport tibia nail (NuVasive Specialized Orthopedics) that did not fit the dimensions of previously designed extractors is presented. Additionally, a strategy to manage the residual tibia vara and docking site nonunion is described.

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Conflict of interest: None

Patient consent statement: The author(s) have obtained written informed consent from the patient for publication of the case report details and related images.

Case Description

Clinical History and Treatment Strategy

A 42-year-old previously healthy male was referred for assessment and management of a critical right tibia bone defect 7 weeks after a motor vehicle accident. The patient sustained a Gustilo type IIIB segmental open fracture of the right tibia, a Gustilo type IIIC open fracture of the left tibia, and a closed left femur fracture. The right segmental tibia fracture was managed with a standard reamed and locked intramedullary nail (IMN) and a cement spacer for the bone defect. The bone defect measured 92 mm. Upon assessment at our institution, the patient presented with a wound dehiscence over the right tibia fracture site. The patient was taken to the operating room for IMN revision and cement spacer exchange with irrigation, debridement, and soft tissue coverage. With collaboration from the plastic surgery team, a gastrocnemius-soleus flap and a split thickness skin graft were performed for definitive soft tissue management. Perpendicular geometric cuts of the bone segments were performed during nail revision to allow for subsequent bone transport (Fig. 1).

The patient was treated with 6 weeks of intravenous antibiotics for a fracture-related infection. Three months postsurgery, he showed no signs of wound or hardware infection. Therefore, the patient returned to the operating room for bone defect management with an all-internal strategy using the PRECICE bone transport system. After flap elevation, the temporary cement spacer was removed. The previous IMN was removed, and the canal was reamed to a 12-mm diameter to allow for the use of a 10 × 380 mm PRECICE bone transport nail. Following a 1-week latency period, bone transport was initiated. Over the next 2 months, excursion of the first 30 mm was successfully achieved. Then, the segmental fragment was transitioned onto the second transport segment. At the 63rd day of distraction, the transport segment screw lost fixation and retracted from the docking site. The loose screw was promptly removed, and the transport segment was secured with two interlocking bolts. Bone transport resumed until the transport segment reached the docking site. Once callus was observed at the docking site 3 months post-PRECICE bone transport nail insertion, weight-bearing was permitted as tolerated. Thirteen months following bone transport, the patient reported increasing pain and difficulty weight-bearing. Imaging of the right tibia revealed evidence of a broken PRECICE nail through the lengthening gearbox and a right tibia nonunion at the docking site (Fig. 2). Additionally, varus limb alignment was noted on standing hip-to-ankle radiographs (Fig. 3). Given the docking site nonunion, varus limb alignment, and the broken implant, the patient underwent removal of the broken lengthening nail and application of stacked hexapod frames for bifocal treatment (limb realignment and compression of the docking site).

Surgical Technique of Implant Removal

During the removal procedure, all distal and blocking screws in the proximal segment were removed. The intramedullary canal was accessed proximally through the previous incision using a guidewire and a 10-mm reamer. The nail cap was removed, and the proximal

Fig. 1: Antero-posterior radiograph of the right tibia and fibula following the placement of an IMN and cement spacer for fixation of the right tibia following a Gustilo type IIIB segmental open fracture, leaving a 92-mm bone defect

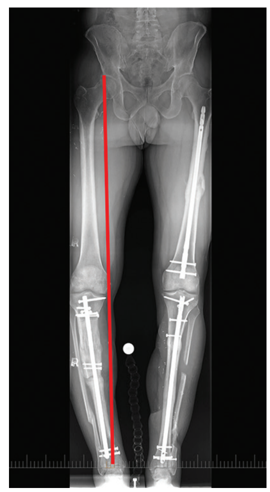
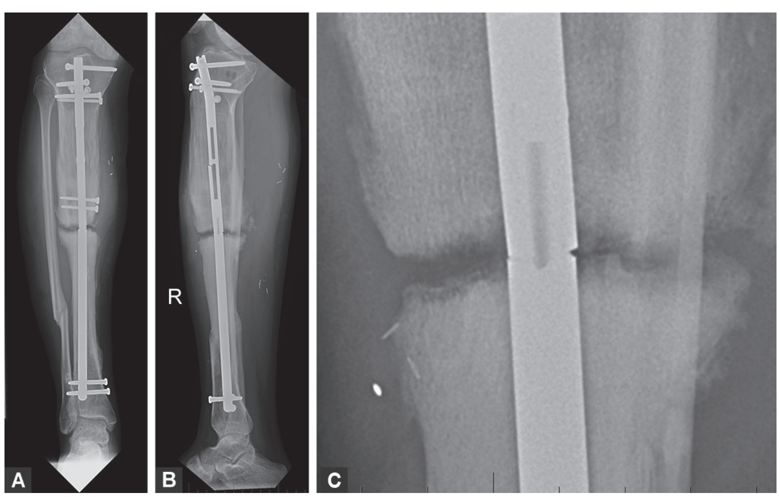
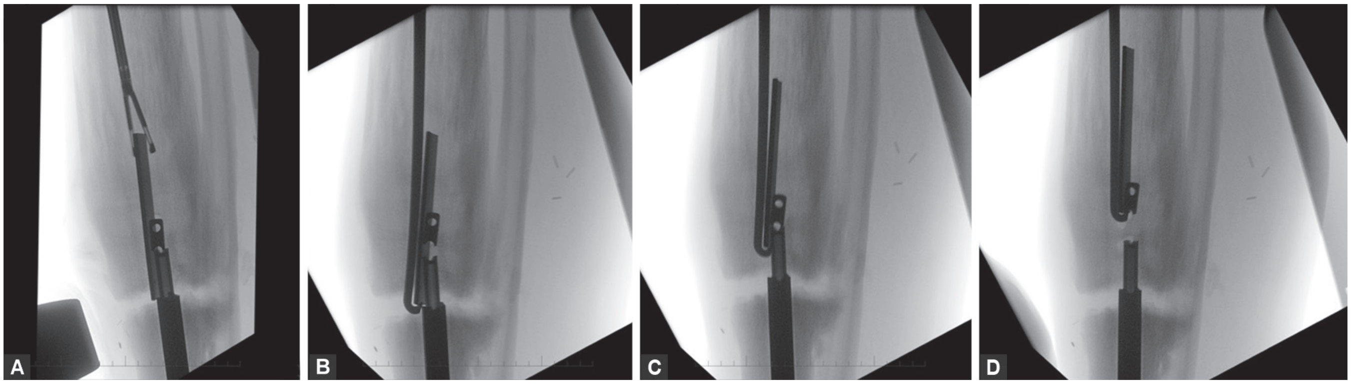


Fig. 3: Standing hip-to-ankle radiograph demonstrating varus limb alignment of the right lower extremity



Figs 2A to C: Radiographs of the right tibia and fibula demonstrating a broken PRECICE tibial nail and presence of a nonunion at the docking site. Antero-posterior (A), Medial (B), Zoomed-in (C) views of the tibia and fibula



Figs 4A to D: Intraoperative fluoroscopy demonstrating proximal PRECICE bone transport system removal within the medullary canal of the right tibia. (A) Retrieval of the loose components of the proximal system was unsuccessful using long laparoscopic graspers; (B to D) Given the canal's width preventing the graspers from opening around the piece, a thin curved hook was used to remove the proximal parts

Figs 5A and B: Images of the distal portion of the broken PRECICE bone transport system with a 5 × 5 mm hole made using a high-speed carbide burr on the anterior aspect of the nail proximal to its lubricating cannister. Zoomed-out (A) and zoomed-in (B) views of the distal nail

nail fragment was extracted through the original nail entry point using the standard handle. Initial attempts to withdraw the loose components of the system using long laparoscopic graspers were unsuccessful secondary to the width of the canal, preventing the graspers from opening around the implant (Fig. 4A). Instead, a thin curved arthroplasty bone hook from the Moreland set was inserted through the proximal entry point and was utilised to retrieve the remaining parts (Figs 4B to D). Nonetheless, the distal nail segment remained fixed at the diaphyseal isthmus of the tibia. At this level, the nail is solid. An anterolateral approach to the nonunion site was performed, and the nonunion site was debrided. Five samples were sent for culture, and one tissue specimen was sent to pathology. Given that the remaining fragment's leading edge consisted of a rail, which is smaller in size than the nail, a laparoscopic grasper was used to extract the nail by approximately 10 mm to gain access to the nail's thicker part through the nonunion site. The PRECICE nail's distal portion houses a cannister containing lubricating products designed to facilitate smooth movement. Hence, a 5 × 5 mm hole in the nail proximal to the cannister was made via the nonunion site using a high-speed carbide burr (Fig. 5). To complete the extraction, a thin Moreland hook was inserted inside the burr hole through the proximal nail entry point (Figs 6A and B). The nail's distal segment was extracted using the Moreland hook and a slotted mallet (Figs 6C to E). The patient's wounds were closed, and the patient was immobilised in an above-knee splint.

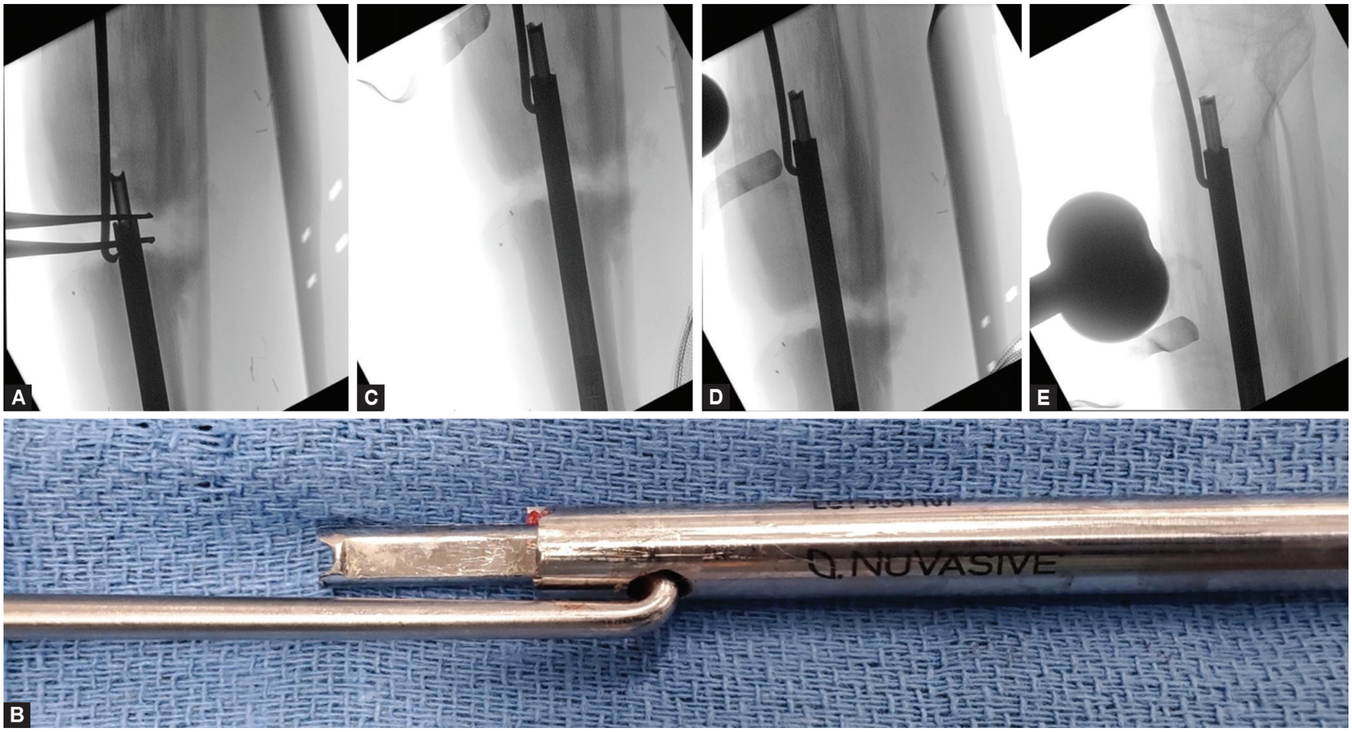
Treatment of Residual Deformity and Nonunion

The patient returned to the operating room 6 days later for application of a double-level hexapod and fibula osteotomy. All cultures remained negative. The proximal frame and osteotomy were used to correct the varus deformity of approximately 15°, whereas the distal frame was applied to compress the nonunion at the original docking site. Compression was initiated immediately and maintained for 1 week, followed by varus correction for 16 days (Figs 7A and B). Compression at the docking site was sustained after removing the proximal ring (Fig. 7C). At follow-up, the fracture site demonstrated appropriate consolidation and alignment, prompting hexapod removal (Fig. 8). The patient returned to full weight-bearing on the right lower extremity and had a favourable evolution with no complications 24 months after hexapod removal.

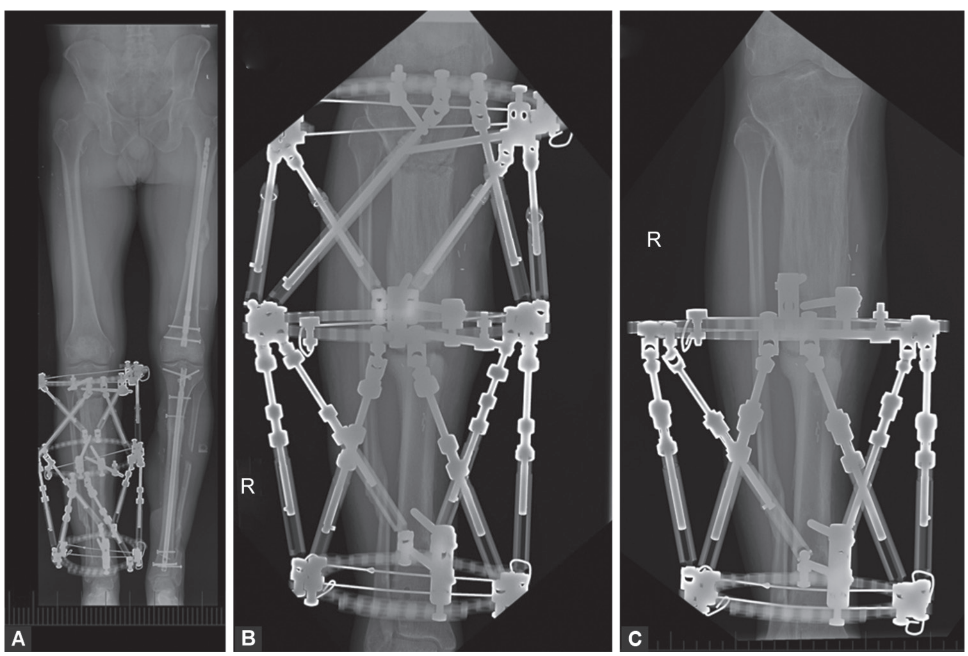
Discussion

Bone transport with magnetic IMNs offers a novel treatment option for the management of leg length discrepancy and critical bone defects. Nevertheless, these implants are not immune to cyclical loading and failure. A recent study by Lee et al. identified that nail bending or breakage occurs in up to 31% of cases, with a higher risk observed in smaller-diameter nails.[7] Several factors may lead to higher rates of mechanical failure, including delayed bone consolidation and premature weight-bearing.[8] Hence, proper patient education and regular follow-ups are required to prevent these complications.

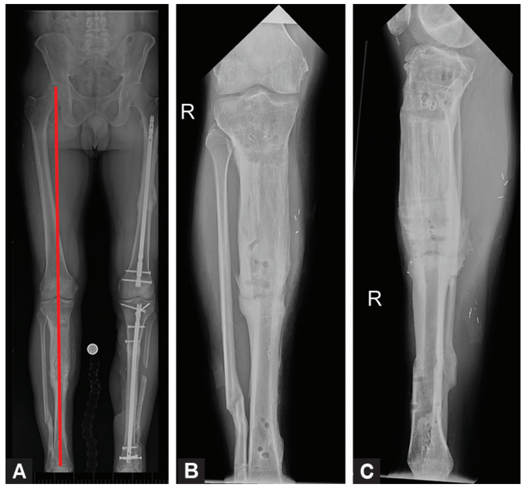
Removal of bent or broken non-cannulated nails remains challenging for surgeons. Careful preoperative planning should be undertaken to safely and efficiently extract the broken implants. While several techniques are described for removing standard cannulated IMNs, reports describing IMLN retrieval techniques are limited.[9–11] Hidden et al. described the extraction of a PRECICE femur nail without disrupting the osteogenesis site.[12] The nail's proximal part was threaded onto the extractor, but its telescoping mechanism dissociated. Thus, the lengthening construct was disengaged form the outer sleeve using an endoscopic grasper, and the remaining distal portion of the nail was cannulated with stacked ball-tip guidewires to provide a press fit and allow its



Figs 6A to E: Intraoperative fluoroscopic and postoperative images demonstrating the technique used for the removal of the broken distal PRECICE bone transport system in the right tibia. (A and B) A thin Moreland hook was inserted into the burr hole on the anterior aspect of the distal nail; (C to E) The nail was then removed using the hook and a slotted mallet through the original nail entry point



Figs 7A to C: Postoperative radiographs of external fixation of the right tibia using a Taylor spatial frame following removal of the PRECICE bone transport system. (A and B) The proximal frame was used to correct a varus deformity of 15°; (C) The proximal frame was removed after 23 days, while the distal frame was retained to compress a tibial nonunion



Figs 8A to C: (A) Postoperative radiographs demonstrating consolidation of the right tibia and correction of the varus deformity 2 weeks after removal of the frame. Full-length standing antero-posterior; (B) Antero-posterior tibia/fibula; (C) Medial views

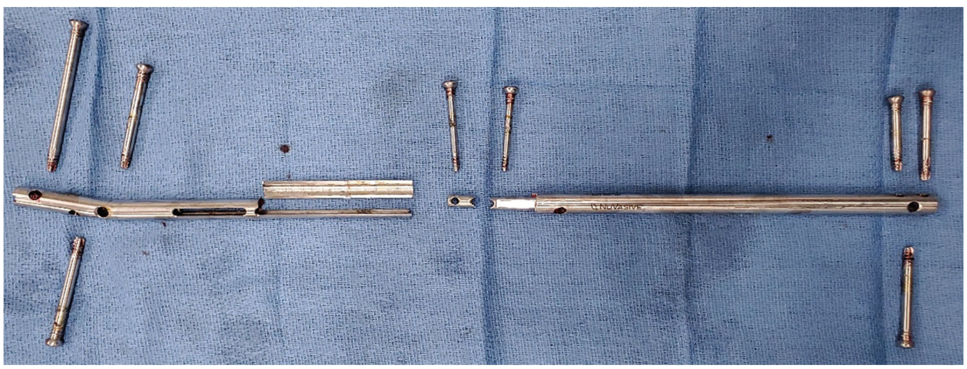


Fig. 9: Components of the broken PRECICE tibia bone transport system following removal

removal through its original proximal entry point. In contrast, Johnson et al. extracted the proximal component of a broken femur IMLN with a tapered extractor, leaving behind the nail's telescoping mechanism and distal portion within the medullary canal.[13] The distal portion was subsequently removed using a long endoscopic pituitary rongeur. In a third case report, Tiefenbock and Wozasek managed a broken PRECICE tibia nail by removing the proximal nail using an extraction device, performing an osteotomy, and recovering the distal nail with a pair of forceps through the fracture site.[5]

Given the lack of specific tools for the retrieval of broken IMLNs, preoperative removal planning requires consideration of multiple factors.[12] Patient anatomy, post-traumatic deformity, fracture location at the level of the nail, and union of the fracture site are all factors that can influence removal technique. Due to the restrictions imposed by the medullary canal's width and the solid nature of the nail's distal portion, the previously described techniques could not be applied. The distal portion of the nail was drilled using a carbide burr through the nonunion site, which then allowed for nail retrieval with a Moreland hook without having to perform a separate osteotomy. To the authors' knowledge, this technique for non-cannulated IMLN retrieval is yet to be described. The PRECICE bone transport system's intrinsic mechanism and components are complex (Fig. 9). During removal, a NuVasive representative was present to assist our team and ensure safe nail extraction. Due to the nail's lubricating cannister within its distal portion, recommendations were made to avoid this component and create the retrieval hole more proximally in the distal fragment (Fig. 8). Hence, proper discussion and preoperative planning with the implant manufacturer proved critical to ensure safe removal of the IMLN.

Conclusion

The removal of a broken non-cannulated IMLN remains difficult given the lack of dedicated instrumentation and solid nature of the nail. Altering the nail through bone defects or nonunion sites can limit bone loss during the extraction process and help safely remove the implant without compromising limb reconstruction. Following nail removal, management of the residual deformity and nonunion with stacked hexapod frames can lead to favourable clinical and radiographic outcomes.

Clinical Significance

Few techniques have been described for the safe removal of non-cannulated IMLNs without compromising bone salvage. This case outlines that altering the implant through the nonunion site is an efficient technique to facilitate removal without creating further bone loss.

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