

Case Report

Retained Male Component After Intra-operative Dissociation of a Tibial Magnetic Lengthening Nail: A Case Report covering Technical Challenges and Management Strategies

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Background

Magnetically driven telescopic intramedullary lengthening nails permit internal distraction osteogenesis without external fixation. While removal is typically uncomplicated, component dissociation at the telescoping junction has been reported as an infrequent but challenging complication.

Case Presentation

A 17-year-old female with congenital posteromedial tibial bowing underwent tibial lengthening at age 13 using a PRECICE tibial nail (8.5 × 155 mm). Planned implant removal was delayed due to the COVID-19 pandemic. At removal 4 years post-surgery, intra-operative dissociation occurred at the telescoping junction. The female (magnetic) component and interlocking screws were successfully removed, but the male

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(non-magnetic) component could not be safely extracted despite multiple retrograde techniques and was left in situ to avoid cortical window creation and possible iatrogenic fracture. At 3 months, the patient remained asymptomatic and had returned to unrestricted activity.

Discussion

Published reports describe retrieval of dissociated or broken magnetic lengthening nails using cortical window or unroofing osteotomy techniques. In this case, delayed retention and the distal flare geometry of the smallest tibial nail may have contributed to mechanical capture, but this remains hypothesis-generating rather than proven.

Conclusion

Surgeons using magnetic lengthening nails should anticipate potential dissociation during removal, particularly when removal is delayed beyond consolidation. Pre-operative planning should include availability of instruments for escalation and frank patient counselling regarding potential for retained hardware. Early planned removal after achieving lengthening objectives may reduce complication risk.

INTRODUCTION

Magnetically driven, telescopic intramedullary lengthening nails have transformed limb reconstruction by enabling internal distraction osteogenesis and eliminating the soft tissue complications, pin-site infections, and patient burden associated with external fixation (Wagner et al. 2017). The PRECICE system (NuVasive Specialized Orthopedics, San Diego, CA) uses an internal magnetic mechanism to achieve controlled, gradual lengthening via external remote controller application, and has demonstrated favourable clinical outcomes for congenital and post-traumatic limb length discrepancies (Wiebking et al. 2016).

Despite these advantages, the telescoping design creates a mechanical junction that may be vulnerable to complications during both lengthening and removal. Component dissociation has been reported during routine hardware removal in femoral nails (Johnson et al. 2021), and retained fragments requiring advanced retrieval techniques have been documented in tibial applications (Dharamsi et al. 2022; Rölfig et al. 2021). However, the specific challenge of retained male (non-magnetic) components and the technical management strategies for this scenario have not been thoroughly characterised in the literature.

This case report presents intra-operative dissociation during delayed planned removal of a tibial magnetic lengthening nail, outlines the intra-operative management of this complication, and reviews reported retrieval strategies while proposing factors that may contribute to component retention risk.

This case report is presented in accordance with CARE (Case Report) guidelines (Gagnier et al. 2013).

CASE PRESENTATION

PATIENT INFORMATION AND INITIAL MANAGEMENT

A female patient presented with posteromedial tibial bowing evident at birth. Conservative management with splinting was undertaken during early childhood. At 11 years of age, she was referred to our institution for evaluation of a

3 cm limb length discrepancy affecting the left lower limb, attributed to the underlying bowing deformity.

INDEX PROCEDURE: TIBIAL LENGTHENING

At 13 years of age, the patient underwent left proximal tibial osteotomy and gradual lengthening using a PRECICE tibial intramedullary lengthening nail (8.5 × 155 mm—the smallest diameter and shortest length available in the tibial PRECICE system). Proximal and distal interlocking screws were placed according to standard technique. The external magnetic remote controller was used post-operatively to achieve gradual distraction at the osteotomy site. Pre-operative consent specifically included discussion of difficult extraction, implant dissociation, breakage, retained hardware, cortical window, osteotomy, and possible need for further surgery.

POST-OPERATIVE COURSE AND CONSOLIDATION

Serial radiographs during the distraction phase demonstrated satisfactory alignment and progressive lengthening. The patient achieved the target length correction, and subsequent imaging confirmed bony mature consolidation at the osteotomy site at 4 years post-surgery (Figure 1 and 2). Clinical reviews during this period were uneventful.

PLANNED REMOVAL AND PANDEMIC-RELATED DELAY

Implant removal was advised approximately 2 years post-surgery, in accordance with typical practice for magnetic lengthening nails. However, the patient missed scheduled follow-up appointments during the COVID-19 pandemic. Following resumption of elective services, she was recalled and again counselled for implant removal.

Figure 3 shows X-rays that were taken just 2 weeks prior to the removal of implant surgery.

The indication for removal included completion of the clinical objective (limb length equalisation), avoidance of long-term retention of rare-earth metal magnets, and patient preference to avoid permanent implantation.



Figure 1. Post-operative radiograph post insertion of PRECICE nail with stabilizing screws

IMPLANT REMOVAL PROCEDURE AND INTRA-OPERATIVE COMPLICATION

Pre-operative planning: Implant specifications were reviewed from the operative record. Standard extraction instruments were prepared.

Surgical approach: A standard anterior approach to the proximal tibia was performed. The previous surgical incision was utilised. Dissection was carried down to identify the proximal interlocking screws.

EXTRACTION SEQUENCE

1. Proximal interlocking screw removal: All proximal locking screws were identified and removed without difficulty.
2. Attempted extraction of the nail: Standard extraction technique was initiated. During manipulation, dissociation occurred at the telescoping junction between the female (magnetic) and male (non-magnetic) components.
3. Female component and distal screw removal: Following recognition of dissociation, the female (magnetic) component was successfully extracted from the proximal aspect. The distal interlocking screws were then identified and removed.
4. Attempted retrieval of the male component (retrograde techniques).
 - Manual distal pressure was applied under fluoroscopic guidance. No distal migration was observed.
 - Progressive increasing force was applied using Titanium Elastic Nails (TENS) to maneuver and

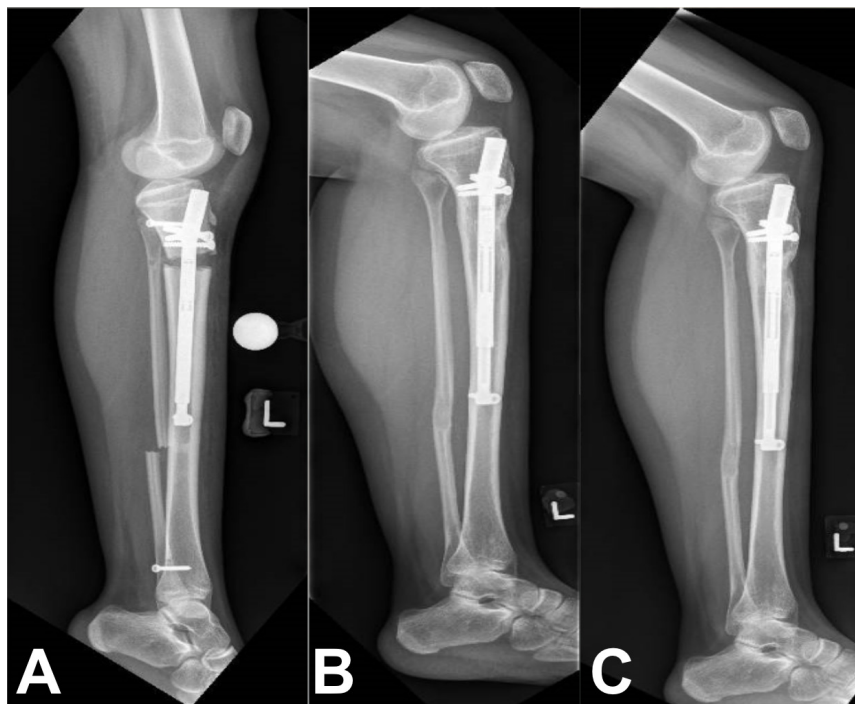


Figure 2. Serial radiographs illustrating interval distraction and lengthening. Post-operative (A) 2 weeks (B) 2 years (C) 4 years.



Figure 3. X-ray images showing radiographic bone remodelling and osseous apposition adjacent to the distal flare of the retained segment . (A) Antero-lateral view of the left leg. (B) Lateral view of the left leg. (C) Close up of osseous ingrowth around the “bell-bottom” tip.

dislodge the component. The fragment remained fixed in position.

- Fluoroscopy confirmed that the male component was mechanically captured within the tibial canal with no appreciable movement despite sustained force.
- 5. Intra-operative decision-making: After multiple unsuccessful extraction attempts, the surgical team weighed the risks and benefits of escalation:
 - Considered: Creation of a distal cortical window to apply additional retrograde force or enable direct visualisation and grasping of the fragment.

- Risk assessment: Concern for iatrogenic tibial fracture given the patient's age, bone quality, and the number of prior attempts. Additional bone work would create a cortical defect requiring potential plating and prolonged rehabilitation.
- Decision: The male component was left in situ to preserve structural integrity of the tibia.

Intra-operative fluoroscopy findings : The female component was located in the proximal tibial shaft and was successfully removed (Figure 4). Post removal intra-operative fluoroscopy shows the retained male component located in the mid-to-distal tibial shaft, with empty interlocking screw holes visible proximally (Figure 5). The distal tip of the retained segment with bell-bottom geometry appeared to be in contact with surrounding cortical bone, creating a potential mechanical catch point (Figure 5). No evidence of iatrogenic fracture from attempted extraction is present.

Operative time: 1 hour 30 minutes

Estimated blood loss: 50 milliliters

Intra-operative complications: Component dissociation with retained hardware (as described)

POST-OPERATIVE RECOVERY AND FOLLOW-UP

Post-operative recovery was uneventful. The patient was counselled regarding the retained male component, including the risks, surveillance plan, and indications for future removal. As long-term outcome data for retained male components of magnetic tibial lengthening nails are lacking, a pragmatic surveillance plan was adopted. Radiographic surveillance was recommended with antero-postero (AP) and lateral tibial radiographs at 6 weeks, 3 months, 6 months and 12 months after the index removal attempt, followed by annual review for at least 2 years or earlier if symptoms arise. Clinical symptoms or radiographic triggers such as localised pain at the area of retained hardware, infection, implant migration, cortical erosion, progressive lucency or loosening, or the need for fixation of a new tibial fracture, would warrant reconsideration for surgery.

Because long-term outcome data for retained male components of magnetic tibial lengthening nails are lacking, we adopted a pragmatic surveillance plan. We recommend AP and lateral tibial radiographs at 6 weeks, 3 months, 6 months, and 12 months after the index removal attempt, followed by annual clinical review with repeat radiographs for at least 2 years or earlier if symptoms arise. Clinical or radiographic triggers for reconsidering surgery include pain localised to the retained segment, infection, implant migration, cortical erosion, progressive lucency or loosening, or the need for fixation of a new tibial fracture.

FOLLOW-UP STATUS

The patient was informed immediately post-operatively regarding implant retention. Her post-operative course was

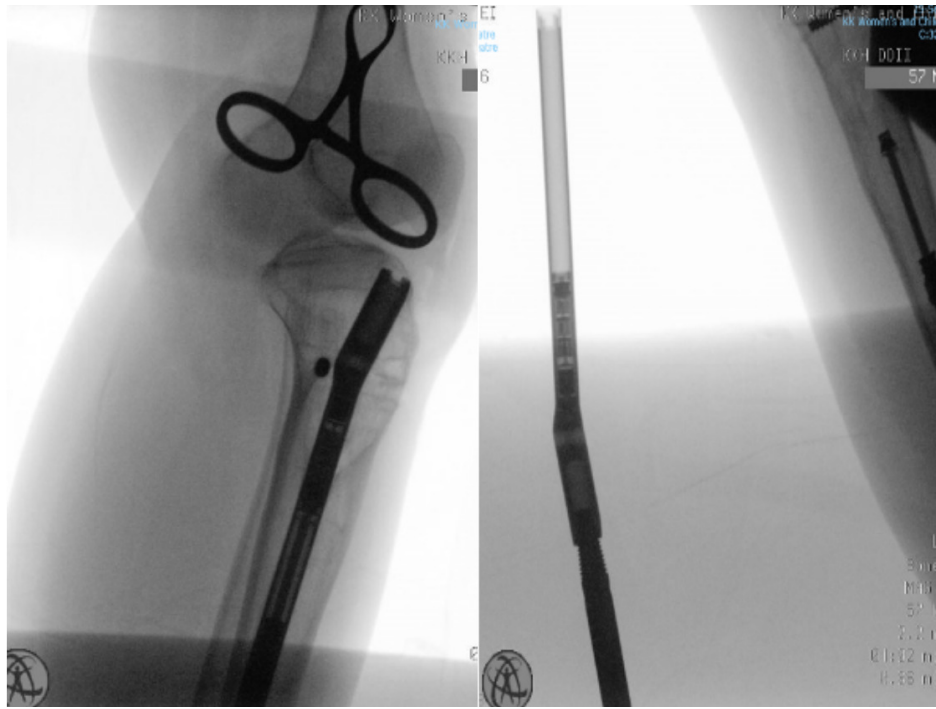


Figure 4. Female component in the proximal tibial shaft before successful removal (left) and female component intact after removal with retained male component in tibia (right).

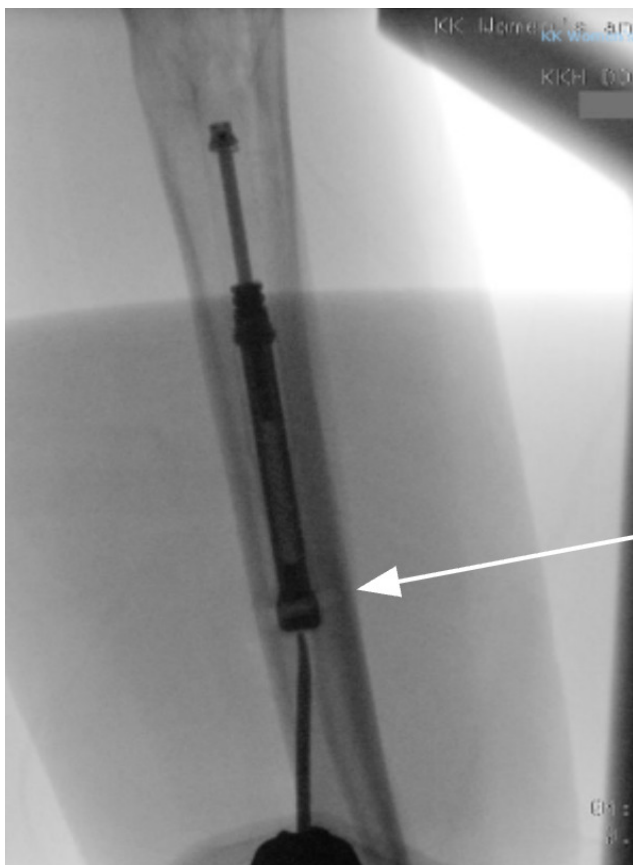


Figure 5. Retained male component located in the mid-to-distal tibial shaft.

otherwise uncomplicated, and she was discharged on post-operative day one. At the 2-week outpatient review, the

surgical wounds had healed completely. She demonstrated full range of motion of the knee and was ambulating independently without assistive devices. At the 3-month follow-up, she reported no pain on full weight bearing or functional limitations and had returned to sports and her pre-operative physical activities without difficulty. She was given an open appointment date.

Overview timeline of the case is described in [table 1](#).

DISCUSSION

CONTEXT AND LITERATURE SYNTHESIS

This report describes intra-operative dissociation during removal of a tibial magnetic lengthening nail with retention of the male (non-magnetic) component. While magnetic lengthening nails have transformed limb reconstruction by eliminating external fixation, their telescoping junction represents a potential mechanical vulnerability during both lengthening and removal. Component dissociation has been reported in femoral nails during routine removal (Johnson et al. 2021), and in tibial nails requiring advanced retrieval techniques (Dharamsi et al. 2022; Rölfling et al. 2021), but the specific challenge of retained male segments has not been thoroughly characterised.

Several case reports document retrieval challenges when magnetic lengthening nails fail or dissociate. Dharamsi et al. (2022) described successful retrieval of a retained tibial magnetic rod fragment using unroofing osteotomy followed by plate stabilisation, demonstrating that aggressive bone work can be necessary when standard extraction fails (Dharamsi et al. 2022). Rölfling et al. (2021) reported techniques for removing broken PRECICE STRYDE nails, includ-

Table 1. Timeline table of case presented

Timepoint	Event	Key Findings/Decisions
Birth	Posteromedial tibial bowing identified	Conservative management with splinting
Age 11 years	Referred for limb length discrepancy	3 cm LLD (left lower limb) secondary to bowing deformity
Age 13 years	Tibial osteotomy and lengthening	PRECICE tibial nail 8.5 × 155 mm inserted. Proximal and distal screws were placed. Begun gradual distraction
Post-operative period	Distraction and consolidation	Serial radiographs: satisfactory alignment, progressive lengthening, bony consolidation achieved
~ 2 years post-surgery	Planned implant removal advised	Appointment missed (COVID-19 pandemic disruption)
~ 4 years post-surgery	Recalled and removal re-advised	Patient counselled with elective removal planned
Intra-operative (age 17)	Implant removal attempted	Component dissociation occurred. Female component removed along with screws. Male component retained in situ
Post-operative	Recovery	Uneventful recovery. Patient counselled on retained hardware

ing creation of a distal cortical window to apply retrograde force to entrapped fragments—a strategy we considered in the present case but elected not to pursue due to fracture risk after multiple failed attempts (Rölfling et al. 2021). Johnson et al. (2021) documented femoral nail dissociation during routine removal but were able to extract both components after recognition of the problem using an endoscopic pituitary rongeur (Johnson et al. 2021).

In contrast to these reports where retrieval was ultimately achieved, this case resulted in permanent retention despite multiple attempted techniques. This difference may reflect the specific geometry of the retained male segment, the degree of osseous ingrowth after 4-year retention, or tibial canal anatomy limiting access compared to femoral applications. The decision to leave hardware in situ when extraction poses fracture risk aligns with risk-benefit principles well established in the broader orthopaedic literature on management of retained implants (Montgomery et al. 2022; Padgett et al. 2022; Cundy and Williams 2024).

Taken together, existing reports emphasise that: (i) dissociation is a recognised but infrequent complication, (ii) multiple retrieval strategies exist but are not uniformly successful, and (iii) risk-benefit assessment must guide escalation decisions. Unroofing osteotomy and cortical window techniques can enable retrieval in selected cases, but these approaches are more invasive and carry their own morbidity. Escalation should be considered early in similar cases, while maintaining a decision threshold that is bone and patient specific. This case adds to this limited literature by documenting factors potentially contributing to retention and highlighting the importance of early removal planning.

A retained intramedullary tibial segment may materially complicate management of any future ipsilateral tibial fracture. The retained male component occupies the medullary canal and may preclude straightforward antegrade tibial nailing, while prior locking screw holes may act as local stress risers (Alford et al. 2007; Rosson et al. 1991). Should

a future tibial fracture occur, treatment options may include staged open retrieval of the retained segment followed by definitive fixation, plate fixation spanning the retained implant, or external fixation depending on fracture location, morphology, and soft tissue status. We therefore counselled the patient that any future ipsilateral tibial fracture would require implant aware pre-operative planning and may not be amenable to standard intramedullary fixation.

CLINICAL IMPLICATIONS

The findings of this case have several implications for surgeons using magnetic lengthening nails.

First, pre-removal counselling should include discussion of dissociation risk and potential need for retained hardware, particularly when removal is delayed beyond consolidation. Informed consent should explicitly address this scenario to manage patient expectations.

Second, operative planning should include availability of instruments for escalation: trephines or oscillating saws for cortical window creation, specialised extraction devices, and reconstruction plates for potential stabilisation if unroofing osteotomy is required. Familiarity with the reported successful removal techniques and appropriate instruments used can guide intra-operative decision-making.

Third, decision making algorithms should balance retrieval persistence against iatrogenic fracture risk (figure 6). This case demonstrates that asymptomatic retained components may be acceptable when infection risk is low and structural integrity preserved (Montgomery et al. 2022). Serial clinical and radiographic surveillance for loosening, migration, or cortical erosion is prudent. Decision making algorithms could be used by surgeons during pre-operative planning for early recognition of dissociation, attempted retrograde extraction techniques, risk-benefit assessment, and escalation decisions. The algorithm branches at key

Proposed Clinical Algorithm for Management of Magnetic Lengthening Nail Removal With Component Dissociation

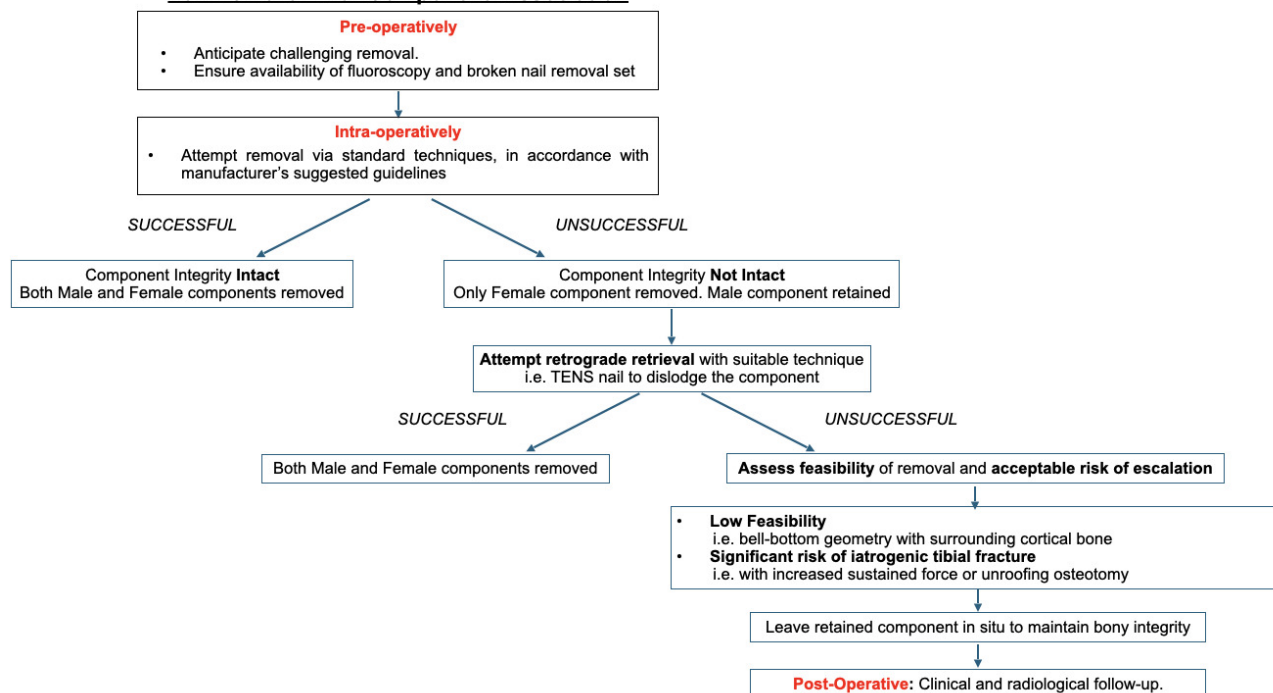


Figure 6. Proposed Clinical Algorithm for Management of Magnetic Lengthening Nail Removal With Component Dissociation

decision points: (i) component integrity during extraction, (ii) success of retrograde retrieval attempts, and (iii) acceptable risk for escalation. When standard extraction fails and escalation poses high fracture risk, leaving hardware in situ with radiographic surveillance is a valid management option. Escalation strategies include cortical window creation with retrograde force application or unroofing osteotomy with fragment retrieval and potential plate stabilisation, as reported by Rölfig et al. (2021) and Dharamsi et al. (2022). Documentation, patient counselling, and informed decision-making should be done at each stage.

Fourth, awareness of implant design features—including distal tip geometry and telescoping junction location—may inform patient specific risk stratification and surgical approach. Preoperative imaging review to assess bone remodelling around the implant may help anticipate retrieval challenges.

Figure 7 shows comparative radiographic documentation of design differences between PRECICE nail sizes. A 8.5 × 155 mm tibial nail (smallest available diameter) was used in the index case, with a distinct “bell-bottom” flare at the distal tip creating a geometric shoulder (highlighted by red circle). Comparatively, larger diameter PRECICE distal nail tips have uniform cylindrical geometry and no distal transition. (red circle shows absence of geometric transition).

The bell-bottom design in smaller nails creates a mechanical catch point when osseous ingrowth occurs proximal to this transition, as hypothesised in the present case. This design feature is unique to the smallest diameter nails and is not present in larger, longer nail variants.

Given the case report level of evidence, these represent expert opinion rather than definitive guidance, and further case accumulation is warranted to develop evidence-based removal protocols.

HYPOTHESISED CONTRIBUTING FACTORS

Several factors may have contributed to retention in this case, though direct causality cannot be established from a single observation:

1. Delayed removal (4 years vs typical 2-year time-frame): Delayed removal and radiographic bone remodelling adjacent to the distal transition may plausibly have contributed to mechanical capture, although causality cannot be established from a single case. In this case, removal was initially planned at 2 years but delayed due to pandemic-related disruption. Whether earlier removal (at the initially planned timeframe) would have prevented retention remains speculative. The optimal removal timing relative to consolidation has not been systematically established in the magnetic lengthening nail literature.

2. Distal “bell-bottom” tip geometry: The PRECICE 8.5 × 155 mm tibial nail—the smallest diameter and shortest available option—features a distal tip with a wider “bell-bottom” or flared geometry, in contrast to the uniform cylindrical profile of larger, longer nails. Radiographic comparison demonstrates this design difference clearly (Figure 7). We hypothesise that new bone formation proximal to this geometric transition may create a mechanical catch or shoulder that prevents distal translation during attempted extraction. Pre-operative radiographs demonstrated bone

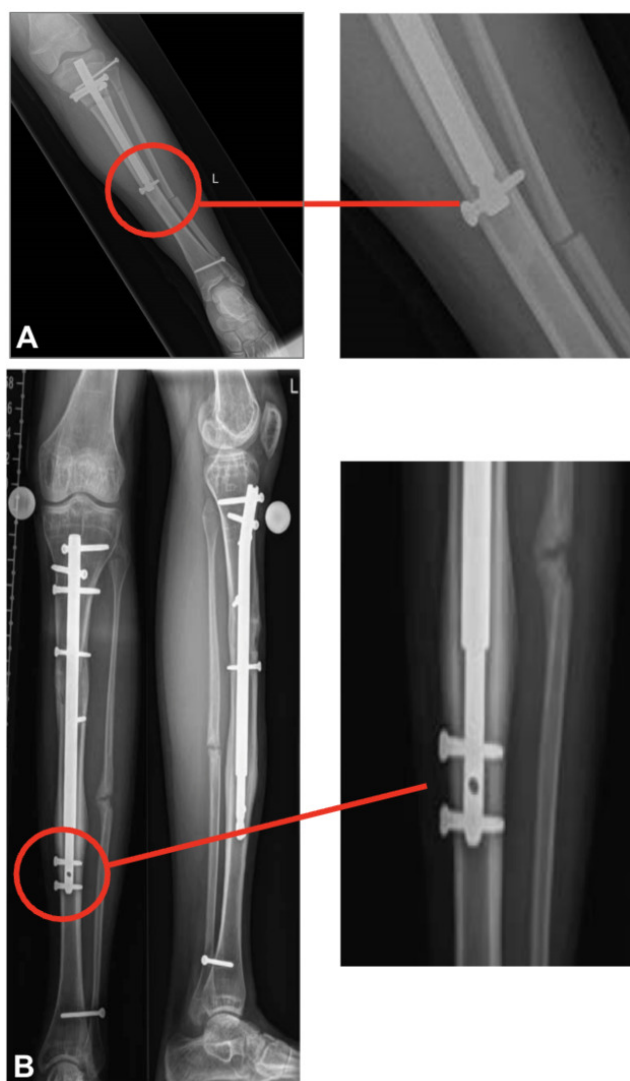


Figure 7. (A) Radiograph of PRECICE 8.5 × 155 mm tibial nail with “bell-bottom” flare distal nail tip; (B) Radiograph of larger diameter PRECICE tibial nail demonstrating uniform cylindrical profile throughout with no distal flare.

remodelling and osseous apposition adjacent to the distal flare of the retained segment, and intra-operative fluoroscopy suggested mechanical capture at this level. However, we cannot confirm true osseous ingrowth or establish causality from plain radiographs and a single case. We therefore interpret delayed removal and distal transition geometry as plausible contributing factors rather than verified causes.

This proposed mechanism requires confirmation through:

- Intra-operative imaging correlation in future cases documenting the exact location of osseous capture relative to design transitions
- Manufacturer design review and engineering analysis of contact forces at the tip geometry
- Comparative case series examining retention rates stratified by nail size/design

3. Small nail size and structural factors: The 8.5 mm diameter represents the smallest available PRECICE tibial nail and may have less structural reserve over time, potentially contributing to mechanical issues. Additionally, the smaller diameter in a relatively narrow tibial canal may have limited manoeuvring space for extraction techniques. Whether this size relationship holds across patients requires further investigation.

Important caveat: These hypotheses are speculative and serve to generate testable questions for future case accumulation, biomechanical analysis, and registry studies rather than definitive explanations. We emphasise the single-case nature of this report and the inability to establish causality.

STRENGTHS

Detailed documentation of the attempted extraction techniques provides practical information for surgeons encountering similar scenarios and contributes to the limited technical literature on magnetic nail removal complications. The explicit description of intra-operative decision-making—including the rationale for choosing to leave hardware in situ—reflects real-world risk-benefit calculus that may inform others’ practice. Integration with existing retrieval literature contextualises this case within the broader evidence base and synthesises reported management strategies. Presentation in accordance with CARE guidelines ensures comprehensive reporting of all relevant clinical details.

LIMITATIONS

Important limitations must be acknowledged. As a single case, generalisability is limited and causal attribution impossible. The absence of intra-operative imaging documenting the exact location and orientation of the retained segment relative to surrounding bone limits mechanistic insight into why capture occurred. The three month follow up may be insufficient to assess long-term sequelae of retained hardware including infection risk, mechanical symptoms, effects on bone integrity, or potential for late migration or loosening, however an open date was given for patient to return should there be issues. Patient-reported outcome measures were not systematically collected using validated instruments. The decision-making process, while documented here, occurred without the benefit of published algorithms or consensus guidance, and alternative surgical teams might have made different escalation choices. Finally, we did not have access to manufacturer engineering specifications regarding the telescoping junction design or failure modes, which would strengthen the mechanistic hypotheses proposed.

FUTURE DIRECTIONS

Future work should focus on: (i) multicentre case series to establish the incidence of dissociation during removal and identify patient and implant factors associated with higher risk, (ii) biomechanical analysis of telescoping junc-

tion failure modes under tensile and rotational loading, (iii) comparative effectiveness research on retrieval strategies (cortical window vs unroofing osteotomy vs acceptance of retention), (iv) long-term registry follow-up of retained magnetic nail components to assess infection, mechanical symptoms, and structural implications, (v) development of evidence-based removal algorithms based on consolidated case experience, and (vi) manufacturer engagement to optimise implant design for both effective lengthening and safe removal, potentially including design modifications to the distal tip geometry or telescoping junction to reduce capture risk.

CONCLUSION

Component dissociation at the telescoping junction during magnetic lengthening nail removal can result in retained hardware that is not safely extractable using standard ret-

rograde techniques. Surgeons should anticipate this risk, particularly when removal is delayed beyond the typical 2-year timeframe, and should have escalation strategies available including instruments for cortical window creation or unroofing osteotomy. Early planned removal after achieving lengthening objectives may reduce retention risk, though this hypothesis requires validation in larger case series. When dissociation occurs and standard extraction fails, the decision to leave hardware in situ may be appropriate to avoid iatrogenic fracture, provided that infection risk is low, the patient is counselled, and surveillance is planned.

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