

Case Report

Extra Articular Tibial Deformity Treated With One Stage Proximal Tibial Osteotomy and Total Knee Arthroplasty: A Case Report With Nine Month Radiographic Union and Excellent Functional Recovery

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Background

Up to 12% of primary total knee arthroplasties (TKA) may be complicated by an extraarticular deformity, which creates special difficulties for acquiring the best possible alignment and ligament balance.

Case

A 60-year-old woman with end-stage tricompartmental osteoarthritis and 12° proximal-third tibial varus malunion underwent single-stage TKA along with metaphyseal open-wedge tibial osteotomy stabilized with a long, uncemented stem spanning the osteotomy site.

Outcomes

The osteotomy healed radiographically at six weeks. The mechanical hip-knee-ankle axis normalized to neutral, the range of motion was improved to 0–130°, and the Knee Society Score rose from 54 before surgery to 92 at four months. Nine months

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postoperatively, the patient was walking unlimited distances without assistance and had a KOOS Jr score of 90. There were no complications.

Conclusion

A metaphyseal tibial osteotomy stabilized only by the TKA stem may allow immediate weight bearing, early union, and good short-term function, indicating that rigid angular criteria for selecting the site of extraarticular correction may be too conservative.

INTRODUCTION

Extra-articular coronal plane deformity is found in up to 12% of primary total knee arthroplasties (TKA) and is a well-recognized risk factor for malalignment, soft tissue imbalance, and early implant failure (Loures et al. 2019). Wolff et al. indicated that deformities $\geq 15^\circ$ in the tibia or $\geq 20^\circ$ in the femur overwhelm the capability of usual intra-articular bone cuts to achieve neutral alignment without sacrificing collateral ligament insertions (Wolff, Hungerford, and Pepe 1991). Follow-up clinical series established that greater intra-articular resection compromises the joint line, requiring release of the collateral ligaments and, at worst, constrained polyethylene liners—all of which have been associated with poorer mid-term functional scores (Wang and Wang 2002; Laskin 2002).

To circumvent these compromises, the surgeon can perform a two-stage osteotomy with delayed TKA or a single-stage extra-articular osteotomy with arthroplasty. The latter, enabled by long stems that span the osteotomy, can recreate the mechanical alignment while leaving ligament tension and joint line height intact, reducing the possibility of instability and polyethylene wear (Catonné, Soriali, Khi-ami, et al. 2019; Sculco et al. 2019). Studies comparing simultaneous osteotomy and staged approaches report comparable implant survivorship but fewer early complications with simultaneous procedures (Oh et al. 2019; Park et al. 2018).

Despite these promising findings, the best management for “borderline” deformities of $10\text{--}15^\circ$ is controversial. We report a case of a 60-year-old female patient with a 12° proximal tibia varus malunion treated with single-stage metaphyseal osteotomy and TKA, describing how stem-only fixation is capable of inducing union rapidly along with superb early function without the dangers of extensive intra-articular resection.

CASE PRESENTATION

PRE-OPERATIVE ASSESSMENT

A 60-year-old woman with a BMI of 29kg/m^2 presented with worsening right knee pain, intermittent knee buckling, and difficulty descending stairs. Fifteen years earlier, she had undergone a tibial tubercle osteotomy (TTO) at an outside facility to address recurrent patellar dislocation. Four weeks after the TTO, she experienced a fall from standing that caused immediate pain in the upper part of her leg. Initial radiographs taken at the outside facility were interpreted as showing no fracture. However, persistent discom-



Figure 1. Pre-operative AP and lateral radiographs of patient's knee.

fort led to repeat imaging ten weeks later, which revealed a proximal-third tibial shaft fracture that was already healing in varus alignment. Since the fracture showed bridging callus, no surgical intervention was offered at that time. Over the years, degenerative changes likely developed due to her varus malunion.

Pre-operative radiographs demonstrated Kellgren-Lawrence grade 4 tricompartmental osteoarthritis, 12° of tibial varus, a 22mm deviation of the mechanical axis toward the medial side of the knee center, and an apex of angulation located 6cm below the joint line (Figures 1 and 2). A follow-up computed tomography scan confirmed the absence of rotational malunion.

Physical examination disclosed active knee motion from 0° to 110° , a varus thrust during gait, and patellar subluxation near full extension. The collateral and cruciate ligaments were intact, and neurovascular integrity was preserved. Preoperative patient-reported outcomes included a Knee Society Score of 54 (pain 24, function 30) and a Knee Injury and Osteoarthritis Outcome Score for Joint Replacement (KOOS JR) of 49.

SURGICAL TECHNIQUE

After induction of regional anesthesia, the patient was positioned supine on a radiolucent table with a tourniquet applied but left deflated. A midline skin incision was carried through the previous scar, and a standard medial parapatellar arthrotomy was performed. Dense fibrous tissue from



Figure 2. Pre operative standing Evolution of Orthopaedic Surgery (EOS) radiograph showing 12° tibial varus and mechanical axis deviation.

the prior tibial tubercle osteotomy (TTO) was sharply excised to facilitate exposure.

The two TTO cortical screws were removed. Attention then turned to the extra-articular deformity. Under biplanar fluoroscopic control an oblique medial open-wedge osteotomy was created six centimeters distal to the tibial plateau at the apex of the varus malunion ([Figure 3](#)). A laminar spreader was gently inserted and opened until a neutral mechanical hip–knee–ankle axis was achieved, as confirmed with an extramedullary alignment rod extending from the center of the femoral head to the center of the ankle mortise.

A surgical assistant steadied the correction by holding laminar spreader and distal leg during tibial preparation. The tibial canal was sequentially reamed to accommodate a 15-mm diameter, 150-mm press-fit stem. Standard measured-resection technique was used on the femur with an intramedullary guide set to 6° of valgus. Femoral rotation was set to 4° of external rotation relative to the posterior condylar axis and parallel to the trans epicondylar axis—an amount chosen to optimize patellar tracking without overstuffing the lateral compartment. The tibial proximal cut was made perpendicular to the mechanical axis with a targeted posterior slope of 3°. Initial tibial component rotation was referenced to the medial one-third of the tibial tubercle and patellar tendon trajectory.

Trial components were inserted and demonstrated balanced flexion and extension gaps and central patellar tracking without the need for lateral release. The tibia was subsequently punched after confirming appropriate rotation for adequate patellar tracking. Final implantation proceeded with pressurized cement for the posterior-stabilized



Figure 3. Intra-operative fluoroscopic image demonstrating tibial osteotomy

femoral component and the tibial baseplate under tourniquet insufflation. The diaphyseal press-fit stem was again confirmed to span the osteotomy by more than two cortical diameters under fluoroscopic guidance ([Figure 4](#)). Autogenous cancellous graft harvested from the femoral chamfer cuts was tightly packed into the osteotomy gap and along the medial cortex. The patella was resurfaced with a medialized polyethylene button.

After copious irrigation, the arthrotomy and extensor mechanism were closed in layered fashion over a closed-suction drain. A sterile dressing and a hinged knee brace locked in full extension were applied. The patient was allowed full weight bearing as tolerated with the brace, and physiotherapy was initiated on post-operative day one. Chemoprophylaxis against venous thrombo-embolism consisted of re-initiation of her home medication of apixaban 2.5 mg twice daily.

POST-OPERATIVE COURSE

The total estimated blood loss was 300 mL, and no transfusion was required. The patient tolerated oral intake on the evening of surgery, completed her first physiotherapy session the following morning, and ambulated fifty feet with a rolling walker while wearing the hinged knee brace locked in extension. Following ambulation, full length lower extremity films were re-obtained, demonstrating neutral mechanical hip–knee–ankle axis ([Figure 5](#)). She was discharged home on post-operative day two with acceptable pain control and an incision that was clean, dry, and intact.

Quantitative range-of-motion and outcome-score data are summarized in [Table 1](#). At the two-week clinic visit the incision was fully healed and sutures were removed.



Figure 4. Intra-operative fluoroscopic image demonstrating adequate spanning of osteotomy site of the tibial stem.



Figure 5. Post operative day 1 standing EOS radiograph demonstrating neutral mechanical axis and stem stabilized osteotomy.

The patient continued full weight bearing in the brace. By six weeks the osteotomy displayed bridging callus across the osteotomy site (Figure 6), the brace was discontinued, and she achieved an unrestricted gait pattern without assistive devices. Four months after surgery, the patient had

resumed activities such as tennis and reported no pain or swelling. Radiographs at that time demonstrated complete cortical union without any interval changes in alignment (Figure 7). At the nine-month assessment she reported hiking up to five miles and skiing on groomed slopes without limitation. Imaging showed continued consolidation of the osteotomy and stable components (Figure 8).

DISCUSSION

Historically, managing extra-articular coronal deformities during TKA has relied on established angular thresholds to determine whether correction should be intra-articular or extra-articular. Historically, tibial deformities exceeding 15° or femoral deformities greater than 20° could not be corrected intra-articularly without risking damage to the collateral ligament attachments (Wolff, Hungerford, and Pepe 1991). Subsequent research has confirmed that aggressive intra-articular resections may elevate the joint line, destabilize the medial collateral ligament, and increase the need for constrained bearings—factors associated with lower Knee Society Scores and higher revision rates when the postoperative mechanical axis deviates by more than 3° from neutral (Wang and Wang 2002; Laskin 2002; Park et al. 2018; Oh et al. 2018).

Our patient presented with a borderline deformity: 12° of metaphyseal varus located 6cm below the joint line. Planning for intra-articular correction suggested an additional 11 mm of medial tibial resection, which would have jeopardized the medial collateral ligament's attachment and raised the joint line by 4mm. Given the patient's high activity goals, the limited options for adjusting joint line elevation (with augment sizes available only in 5 mm, 10 mm, etc.), and the established link between joint line elevation and mid-flexion instability (Laskin 2002), we opted for a single-stage metaphyseal osteotomy stabilized by a long press-fit stem.

Meta-analyses comparing staged high-tibial osteotomy followed by delayed TKA, simultaneous osteotomy and TKA, and aggressive intra-articular bone resection show similar ten-year implant survivorship. However, staged procedures carry higher early complication rates (Oh et al. 2019). Simultaneous osteotomy corrects alignment in one procedure, preserves ligament tension, and avoids a second anesthesia, though it may slightly increase operative time and blood loss. In Catonné's prospective series of 26 knees, all osteotomies healed within three months, and patients achieved a mean International Knee Score of 98 at nine years (Catonné, Soriali, Khiami, et al. 2019)—results that align with the rapid union and excellent early function seen in our case.

Traditional fixation methods often used plates or intramedullary nails, which require more dissection and can interfere with component positioning. Biomechanical studies indicate that a diaphyseal-engaging stem that bypasses the osteotomy by at least two cortical diameters provides rigidity comparable to plate constructs, without the added risk of hardware-related soft tissue irritation (Ishida, Tsumura, Takayama, et al. 2011; Lai et al. 2022). Pa-

Table 1. Chronologic Summary of Objective Outcomes

Visit	Knee ROM ¹ (degrees)	KSS ² Pain/ Function	KOOS JR ³	Activity milestone
Pre-operative	0–110	24/30	49	Varus thrust, stair difficulty
2 weeks	5–95	38/30	—	Walking fifty feet with walker
6 weeks	10–80	42/36	72	Brace discontinued; stair climb without rail assist
4 months	0–130	46/46	88	Returned to sports such as tennis
9 months	0–130	47/48	90	Hiking 5 miles, recreational skiing

1. ROM – Range of Motion

2. KSS – Knee Society Score

3. KOOS JR– Knee Injury and Osteoarthritis Outcome Score for Joint Replacement

**Figure 6. Six week AP and lateral radiographs with bridging callus across the osteotomy gap.****Figure 7. Four month AP and lateral radiographs showing complete cortical union and stable components.**

pagelopoulos et al. reported 100% union with stem-only fixation across deformity sites (Papagelopoulos et al. 2007).

Studies focusing on intra-articular correction for moderate deformities report mean postoperative Knee Society Scores (KSS) ranging from 68 to 85, often requiring constrained inserts or resulting in elevated joint lines (Loures et al. 2019; Wang and Wang 2002). In contrast, simultaneous osteotomy groups demonstrate better functional scores and more durable alignment—Catonné's series averaged a KSS of 98 at long-term follow-up (Catonné, Sariali, Khiami, et al. 2019). Our patient achieved a KSS of 95 and a KOOS JR of 90 at nine months, supporting the idea that restoring neutral mechanics while maintaining ligament tension promotes favorable early function. Registry data further suggest that neutral or slight varus alignment is ideal for implant longevity (Park et al. 2018; Oh et al. 2018), reinforcing the choice of extra-articular correction when

intra-articular techniques would leave residual malalignment.

The major limitation of this report is its single-patient study design with nine-month follow-up. However, the prompt union, neutral mechanical axis, and exceptional functional recovery are consistent with findings from larger prospective cohorts. Future research should include gait analysis, cost-effectiveness data comparing stem-only with plate-assisted fixation, and randomized trials assessing the incremental benefit of navigation or robotic assistance for osteotomy planning.

In summary, single-stage metaphyseal osteotomy stabilized using a long tibial stem can safely manage borderline proximal tibial deformity during primary TKA, achieving rapid union, immediate full weight-bearing, and excellent early patient-reported outcomes. Surgeons should person-

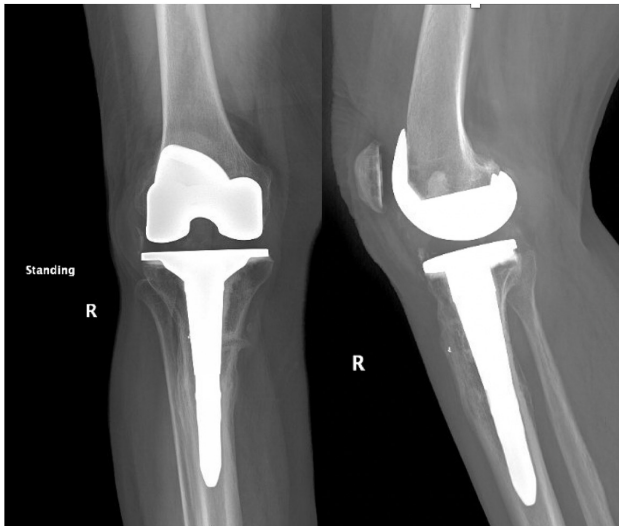


Figure 8. Nine month AP and lateral radiographs confirming maintained alignment, consolidated union, and absence of radiolucency.

alize decision-making rather than adhering to strict, rigid angular thresholds.

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