Tibial Turn-Up in Oncological Reconstruction: Rationale alternative for massive distal femoral bone loss. Case report and review of the literature

Sergio Andres Arroyave Rivera[1], Camilo Soto[2], Luis Gómez[2], Andrea Franco[2], and Juan Chaustre[2]

[1]Nueva Granada Military University Faculty of Medicine and Health Sciences
[2]Instituto Nacional de Cancerologia

October 20, 2023

Introduction

Limb salvage is achievable in most patients (90%) with bone or soft tissue sarcomas owing to chemotherapy and reconstructive surgery advances. However, amputation is needed in some patients due to chronic infection, tumor recurrence, and construct failure (1). Proximal transfemoral amputations result in less energy-efficient walking, increased oxygen consumption, and reduced walking speed (2,3).

Tibial turn-up plasty is a surgical alternative for severe femoral bone defects, avoiding proximal above-knee amputations or hip disarticulations to augment the functional length of the stump. The surgical basis is to use the ipsilateral tibia as a pedicled autograft or free flap, rotating the bone proximally 180º (coronal or sagittal plane) to the remaining femur or hip joint. The result is a longer stump, optimizing prosthetic fitting for more efficient gait balance during mobilization (4).

We herein report the case of a 46-year-old male with a history of conventional high-grade osteosarcoma of the distal left femur who underwent limb salvage with distal femoral endoprostheses. Several years after the surgery, he developed an untreatable periprosthetic infection with substantial femoral bone loss. The tibial turn-up plasty was proposed as an alternative to a proximal above-knee amputation to optimize prosthesis use and potentiate gait balance. The transfemoral prosthesis was fitted 11 months after surgery. At the final follow-up, the patient was ambulatory with a cane without complaints about prosthesis fitting or pain.

Case presentation and investigation

Our patient was a 46-year-old male who initially presented to our orthopedic oncological department at 16 years of age with pain in the lower left limb associated with a growing mass and swelling of the knee. Radiological examination revealed a permeative, mixed lytic, and osteoid-forming lesion arising from the metaphysis of the left distal femur. Initial suspicions were bone primary sarcoma or osteomyelitis.

The biopsy confirmed the diagnosis of conventional intramedullary high-grade osteosarcoma of the left distal femur. Staging investigations ruled out systemic metastatic disease and skip metastases with a resectable bone tumor.

We decided to perform a wide resection of the distal femur and a reconstruction with an osteochondral femoral allograft. One year later, he developed a peri-implant infection requiring 2-stage revision, initially placing an antibiotic spacer with an intramedullary nail for ten months. Then, we performed a reconstruction with another distal femoral osteochondral allograft. Twelve years after the initial procedure, he underwent conversion to knee oncological endoprosthesis due to a distal metadiaphyseal fracture of the femoral allograft.

He developed a late periprosthetic infection eighteen years after endoprosthesis implantation. He was initially treated with several surgical debridements and suppressive antibiotics with the intention of implant retention (Figure *1*).

The x-rays and computational tomography (CT) analysis revealed severe bone loss in the middle femur and septic loosening in the tibial component.

After extensive discussions with the patient, ablative surgery was indicated and opted for due to continuous drainage, non-healing sinus tracts, significant limb length discrepancy, severe joint stiffness, and non-controlled pain. Van Nes rotantioplasty was not considered because of the rigid equinus deformity secondary to limb length discrepancy.

We performed tibial turn-up plasty thirty years after the initial intervention. The goal was to provide additional osseous length and optimize prosthesis fitting, avoiding extremely short transfemoral stump.

Operative technique

The patient was supine under general anesthesia, padding the left gluteal area. The incisions started in the midline of the medial and lateral aspects of the thigh. The medial incision was carried down, starting ten centimeters below the inguinal fold until the distal third of the leg. The lateral incision began from the lateral aspect of the greater trochanter to the same level as the medial incision distally. The anterior flap was cut 10 centimeters proximal to the joint line in the knee and the posterior flap at the distal third of the leg, ensuring the complete excision of the previous scar tissue and sinus tracts (Figure *2*).

We proceeded with distal femur endoprosthesis extraction and aggressive debridement of the infected tissues (Figure *3A*).

The superficial femoral artery and vein were accessed from the medial incision, and careful dissection was performed through the adductor hiatus until the popliteal fossa. At the lower border of the poplìteus muscle, we ligated the anterior tibial artery, and the tibioperoneal trunk was preserved.

The posterior tibial artery was dissected distally and ligated at the level of the distal third of the leg, preserving the posterior tibial neurovascular bundle as distally as possible that is required to provide perfusion and sensation to the flap. Traction neurectomies were performed on the superficial and deep peroneal nerves. The tibial osteotomy and foot amputation were performed at the distal diaphyseal metaphyseal junction approximately 6 cm proximal to the ankle joint. The fasciocutaneous distal cut was made 3 cm distal to the tibial cut. The fibula was disarticulated proximally and excised from the interosseous membrane. It was used later as an autogenous strut graft to augment the medullary canal, bridging the remaining femur and the tibia autograft (Figure *3B*).

The lateral and anterior muscular compartments of the leg were transected completely, and the superficial and posterior muscular regions were preserved with their tibial osseous attachments. Then, the distal tibia and the posterior myofasciocutaneous flap were rotated 180 degrees proximally, joining the distal end of the tibia with the distal end of the femur (Figure *3C*).

The front surface of the tibia was then lying with the posterior compartment and thigh muscles. The osteosynthesis was made with a 4,5 dynamic compression plate alongside the new femorotibial construct, achieving compression between the fragments and with a fibular autograft strut spanning the osteotomy site inside the medullary canals (Figure *3D*). The stump coverage was complete without skin tension of the flaps.

The resultant total construct length using the technique was 35 cm, contrasting to 13 cm in the case of unaugmented amputation (Figure *4*).

Follow up

Subsequently, the patient required three additional surgical debridements during the first month after surgery to achieve adequate healing of the stump.

He underwent postoperative rehabilitation to achieve an early prosthetic adaptation. At ten months postoperatively, a radiographic union of the osteotomy site was evident; his stump healed well with a good hip range of motion. He was allowed to full weight bearing, achieving complete prosthetic fitting 11 months after the surgery. Two years postoperatively, he ambulated with the transfemoral prosthesis using a single cane (Figure 5); he referred to feeling well and resumed his work with minor limitations.

At the most recent follow-up (28 months postoperatively), we applied the MSTS (Musculoskeletal Tumor Society Score, lower limb) (5) with a total score of 18 (pain 4 points, functional capacity 3 points, walking ability 3 points, emotional acceptance 3 points, use of gait support 3 points and gait 2 points. Each of these items was evaluated on a 5-point scale, with a maximum total score of 30 points, assumed as 100%), compared with a total of 7 points before the surgery. The most significant changes were in pain control and improvement in gait pattern. The real proportional gain was 36% (taking 30 points as 100%).

Discussion

Some limb salvage patients with bone sarcomas will undergo amputations secondary to tumor recurrence, mechanical failure, infections, and fractures. Those amputations are frequently proximal transfemoral or hip disarticulations owing to severe distal femoral bone loss. (6).

Patients with higher amputation levels invariably have lower functional scores. Previous studies have demonstrated that a proximal level of amputation is associated with less energy-efficient walking and slower walking speed. In above-knee amputations, the stump length is shown to have a significant impact on the physiological cost index (PCI), increasing metabolic demands by>50% compared with healthy individuals (2,7). Thus, maximizing the stump length provides less impact on the gait balance, with better prosthetic fitting.

Tibial turn-up plasty is a reconstructive procedure used to increase the length of above-knee amputations. The main objective of the intervention is to achieve a longer stump that is functionally superior to proximal transfemoral amputation or hip disarticulation (8).

This procedure is a reasonable alternative in circumstances where reconstruction is not feasible in the context of a tumor recurrence, untreatable osteomyelitis, and severe posttraumatic femoral bone loss (9). A tibial turn-up is also valid in extremely young patients with bone sarcomas, where the predicted limb-length discrepancy is unacceptable. This procedure substantially decreases the need for revision surgeries in those scenarios (1,10).

Historically, the first report of tibial turn-up was described by Sauerbruch in 1922 (11). The original German manuscript was "The extirpation of the Femur with the Plastic Overturning of the Lower Leg." Sauerbruch described the case of a 13-year-old female with chronic posttraumatic osteomyelitis of the femur, treated with surgical debridements without success, and a second case of pathological femur fracture in a male in his forties. Since the initial report, the main objective was to bring an advantage for fitting the prosthesis.

Subsequently, published techniques are modifications to the original article of Sauerbruch (11), all to optimize the femoral stump length.

Borggreve (12) originally described rotantioplasty in 1930 in treating severe limb deformity secondary to tuberculosis. Van Ness published the technique in English literature for the first time in 1948 (13), describing partial and total turn-up plasty. The same author described the "turn-up plasty of the leg" in 1964, reporting the use of fibular strut as an endomedullary autograft for the first time. In 1956, Nicholson and Wider (14) described a tibial turn-up plasty combined with a hip prosthesis, where the femur was excised entirely, and the femoral stem of the prosthesis was fit in the distal part of the tibia after the latter was rotated proximally.

Peterson et al. (15) described a novel technique of rotating the tibia and hindfoot to the hip joint entirely and performing a calcaneopelvic fusion to recreate a new hip through the tibiotalar joint.

In this article, we describe the case of a 46-year-old male with chronic treatment-resistant osteomyelitis of his distal left femur and a prior history of distal femoral osteosarcoma. The above-knee amputation would result in an extremely short femoral stump, and we decided to optimize the length with the tibial turn-up plasty. We followed the same dissection principles as the original description of Sauerbruch

Of the few published articles on tibial turn-up plasty of which we are aware, only 2 two reports utilized the fibular strut autograft in an intramedullary manner to improve structural support and facilitate bone consolidation. Sojka et al. (4) described a similar technique using an intercalary fibular autograft. They reported a 20-year-old man with chronic osteomyelitis with a previous history of metastatic rhabdomyosarcoma of the distal right femur. Instead of rotating the tibia, they fused the distal femur to the proximal tibial, and the fibular strut was used to stabilize the junction. Complementary fixation was performed with a locking compression plate in the femorotibial construct.

Kasis et al. (9) reported the case of a 26-year-old male with severe distal femoral bone loss secondary to a road traffic accident with secondary osteomyelitis. They performed the tibial turn-up with the same surgical principles. However, they used external fixation for the reconstruction, achieving complete consolidation.

Douglas et al. (16) reported one of the most cited series to date regarding functional outcomes. Seven patients with a prior history of distal femur malignancy were included; five patients underwent the procedure because of a failed limb salvage, and two as a primary reconstructive procedure. At the final follow-up, all patients could ambulate with above-knee prostheses. Only one patient, with soft tissue leiomyosarcoma, had tumor recurrence in the pelvis, requiring a hemipelvectomy one year after the procedure.

Ramsey et al. (3) recently published the largest series regarding functional and surgical outcomes in tibial turn-up plasty. They included ten patients between 2003 and 2021 by a single orthopedic oncology division. Ten of the 11 patients were ambulatory at the final follow-up, 80% using a simple assistive device and two ambulating unassisted. This finding is concordant with our patient, who completed the prosthetic fitting 11 months after the surgery and ambulated with the transfemoral prosthesis using a single cane at the final follow-up.

Ramsey series (3) revealed that all patients had chronic infections after arthroplasty or oncologic reconstructions, with a median number of 13 surgeries before turn-up plasty and six of eleven patients underwent at least one reoperation after turn-up plasty, mainly because of wound infection. Our patient exhibited a similar clinical course, requiring more than 20 surgeries before deciding on an ablative procedure, and after turn-up plasty, he underwent irrigation and debridement because of infection.

Our patient showed substantial improvements, especially in function, gait pattern, and pain control, and achieved a complete prosthesis fit. At two years of follow-up, MSTS was 18/30, compared with 7/30 before the intervention. Tate et al. (17) reported the case of a 4-year-old boy with distal femoral osteosarcoma who underwent the procedure. They described an MSTS of 25/30 after two years postoperatively, a higher score than our case, probably because the younger age has better possibilities of social reintegration and participation, and the preservation of proximal tibial physis allowed continuous growing of the stump. However, our patient's proportional change of MSTS was meaningful, with an improvement of 36%.

Conclusions

Currently, limb salvage is achievable in a high proportion of bone sarcomas. However, some patients will undergo further amputations secondary to tumor recurrence, mechanical failure, infections, and fractures. The tibial turn-up plasty is a sound option for those patients presenting with massive femoral bone loss or tumor involvement.

This procedure aims to achieve a longer and more functional femoral stump, facilitating prosthesis fitting and providing less impact on the gait pattern.

There are numerous modifications to the original technique, adapting the reconstruction according to the severity and localization of the femoral bone loss. There is needed more studies to establish if there is any superiority of the surgical modifications.

This procedure is a last-resort reconstructive option with frequent reoperations; however, most patients can ambulate during the follow-up with good functional outcomes.

References

1. Misaghi A, Goldin A, Awad M, Kulidjian AA. Osteosarcoma: a comprehensive review. SICOT-J. 2018;4.

2. Jeans KA, Browne RH, Karol LA. Effect of amputation level on energy expenditure during overground walking by children with an amputation. J Bone Joint Surg Am. 2011 Jan 5;93(1):49–56.

3. Ramsey DC, Fourman MS, Berner EA, Werenski J, Sodhi A, Heng M, et al. What Are the Functional and Surgical Outcomes of Tibial Turnup-plasty for Salvage in Patients With Chronic Lower Extremity Infection? Clin Orthop Relat Res. 2023 Jun 1;481(6):1196–205.

4. Sojka JH, Everhart JS, Skoracki RJ, Mayerson JL. Modified femorotibial turn-up plasty using an intercalary fibular autograft strut, femoral potting, and plate fixation. Curr Orthop Pract. 2017;28(5):503–7.

5. Enneking WF, Dunham W, Gebhardt MC, Malawar M, Pritchard DJ. A system for the functional evaluation of reconstructive procedures after surgical treatment of tumors of the musculoskeletal system. Clin Orthop Relat Res. 1993 Jan;(286):241–6.

6. Kirilova M, Klein A, Lindner LH, Nachbichler S, Knösel T, Birkenmaier C, et al. Amputation for Extremity Sarcoma: Indications and Outcomes. Cancers (Basel). 2021 Oct 1;13(20):5125.

7. Vllasolli TO, Zafirova B, Orovcanec N, Poposka A, Murtezani A, Krasniqi B. Energy expenditure and walking speed in lower limb amputees: a cross sectional study. Ortop Traumatol Rehabil. 2014;16(4):419–26.

8. Lim CY, Katagiri H, Murata H, Wasa J, Miyagi M, Ishida Y, et al. Solution to a complex problem after failed limb salvage surgery of the distal femur: A case report describing the tibial turn-up procedure. J Orthop Sci. 2022 Jul 1;27(4):943–8.

9. Kasis AG, Olecksak M, Dujon D, Saleh M. Femoro-tibial turn-up-plasty (fixator assisted) for infected nonunion of the distal femur. Inj Extra. 2006 Mar;37(3):99–103.

10. Levin AS, Arkader A, Morris CD. Reconstruction Following Tumor Resections in Skeletally Immature Patients. J Am Acad Orthop Surg. 2017;25(3):204–13.

11. Sauerbruch F. Die Exstirpation des Femur mit Umkipp-Plastik des Unterschenkels. Dtsch Zeitschrift für Chir. 1922 Feb;169(1–2):1–12.

12. Borggreve J. Kniegelenkersatz durch das in der Beinlängsachse um 180 gedrehte Fussgelenk. Arth F Orthop. 1930;28:175–8.

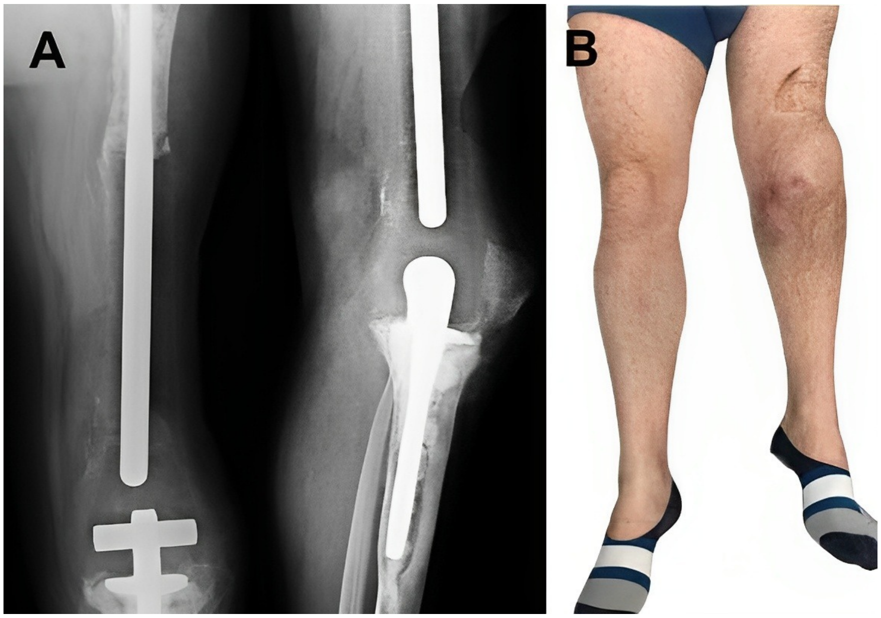
13. Van Nes CP. Transplantation of the tibia and fibula to replace the femur following resection; turn-up-plasty of the leg. J Bone Joint Surg Am. 1948 Oct 1;30(4):854–8.

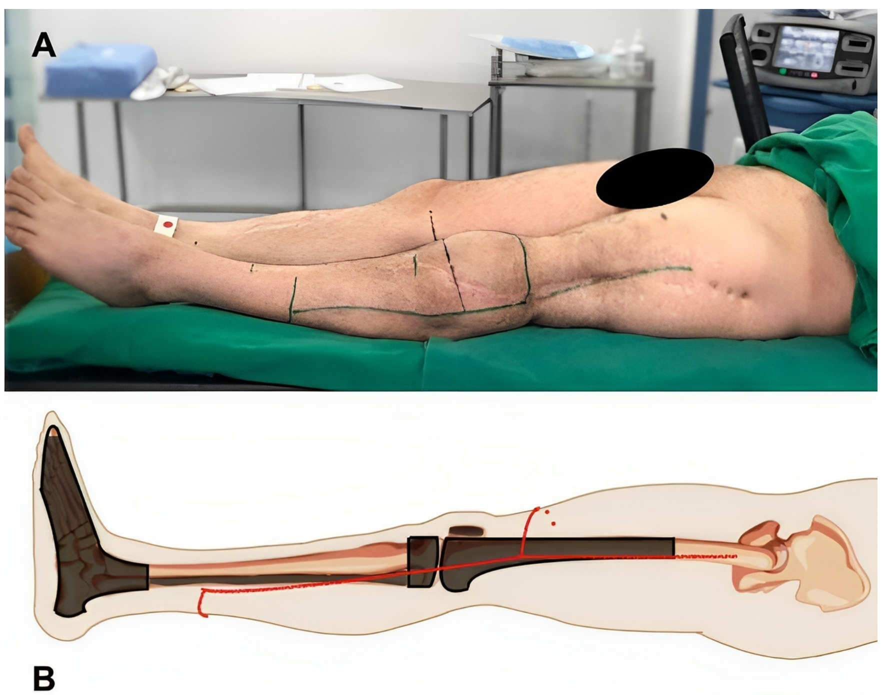
14. Nicholson JT, Wieder HS. Total Resection of Femur with "Turn-up Plasty" of Tibia and Prosthetic Replacement of Hip Joint. Ann Surg. 1956 Aug 1;144(2):271.

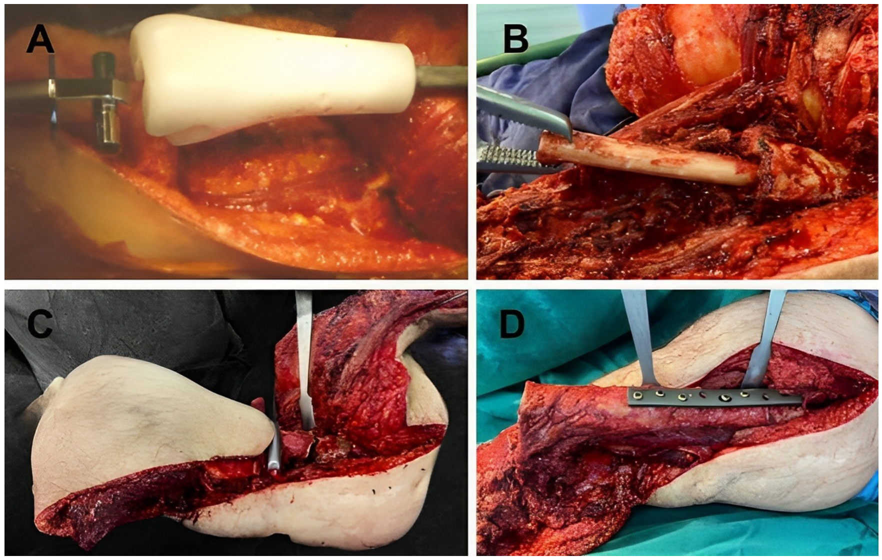
15. Peterson CA, Koch LD, Wood MB. Tibia-hindfoot osteomusculocutaneous rotationplasty with calcaneopelvic arthrodesis for extensive loss of bone from the proximal part of the femur. A report of two cases. J Bone Joint Surg Am. 1997;79(10):1504–9.

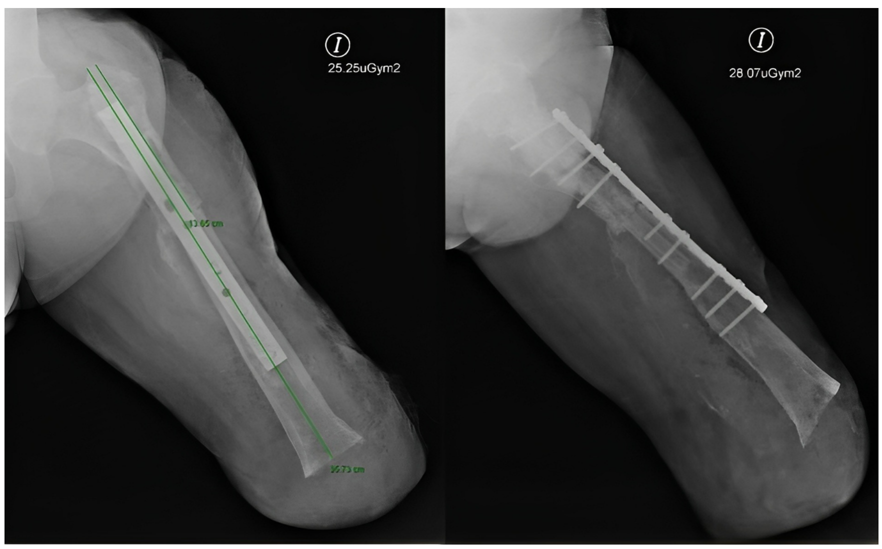
16. McDonald DJ, Scott SM, Eckardt JJ. Tibial turn-up for long distal femoral bone loss. Clin Orthop Relat Res. 2001;383(383):214–20.

17. Tate R, Gerrand C, Hale J. Tibial turn-up procedure as an alternative to rotationplasty in a 4-year-old with osteosarcoma of the distal femur. J Pediatr Orthop B. 2015 Jan 12;24(1):50–5.

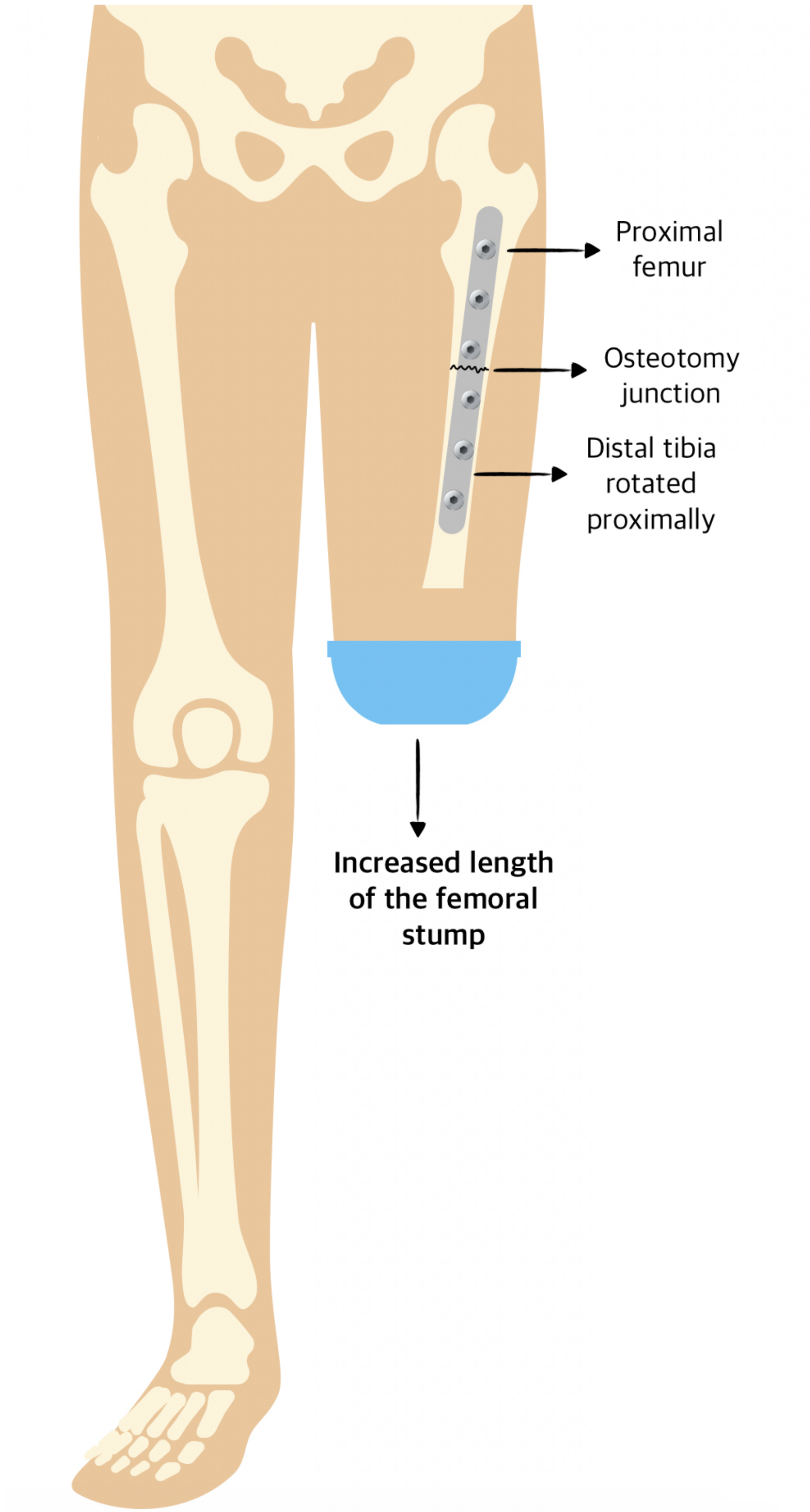

A
B


A
B


A
B
C
D


25.25uGym2
28.07uGym2


A
B


Proximal femur
Osteotomy junction
Distal tibia rotated proximally
Increased length of the femoral stump