International Journal of Research in Orthopaedics
Gaitan-Lee H et al. Int J Res Orthop. 2023 Jul;9(4):844-848
http://www.ijoro.org

DOI: https://dx.doi.org/10.18203/issn.2455-4510.IntJResOrthop20232012

Review Article

Total femoral replacement: a challenging but promising limb salvage option

Hernando Gaitan-Lee[1], Santiago Peña Restrepo[2], Luis José Suárez Jiménez[2], Felipe Guzmán Nalus[3]*, Mariana Piñeros Rincón[3]

[1]Hip and Knee Replacement Group, Pontificia Universidad Javeriana, Bogotá, Colombia
[2]Department of Orthopedic Surgery, Pontificia Universidad Javeriana, Bogotá, Colombia
[3]Pontificia Universidad Javeriana, Bogotá, Colombia

Received: 25 May 2023
Accepted: 17 June 2023

***Correspondence:**
Dr. Felipe Guzmán Nalus,
E-mail: felipeguzman2197@gmail.com

ABSTRACT

Total femur replacement is a limb salvage surgery indicated for patients with oncological and non-oncological pathologies of the femur. Given the characteristics of the patients, there are essential perioperative considerations such as the previous treatment with chemotherapy or radiotherapy, prevention of thromboembolic events, hemorrhage management, and booking of an intensive care unit. As demanding as the surgical technique is, preventing extensive fibrosis, major bleeding, acetabular defects, and changes in normal anatomy is possible. The complications described include infection, structural failure, tumor progression, aseptic loosening, and soft tissue failure. Functional results and survival vary from series to series, but reports exist as high as 70% at ten years.

Keywords: Total femur replacement, Limb salvage, Revision arthroplasty, Total femur arthroplasty, Endoprosthetic replacements

INTRODUCTION

Total femur replacement is a salvage surgery of the lower extremity, whose original description dates back to the year 1965 by Dr. Buchman.[1] Its best-known clinical application is the treatment of neoplastic diseases of the femur; however, in recent years, its use has expanded to arthroplasty revisions for non-oncological causes.[2] It is essential to mention that limb-salvage surgery has successful outcomes reported in the medical literature regarding return to functionality and resolution of disease burden.

Meanwhile, since it comprises major surgery, it can produce complications mainly associated with the patient's overall health condition or inherent to the complexity of the surgical technique, as well as complications attributable to the high mechanical loads supported by the prosthesis.[3] This paper aims to review the state of the art, the technique, and the outcomes of this exciting surgical intervention.

INDICATIONS

Limb salvage seeks to orient functional outcomes in goals such as tolerating limb support. Alternatives to stent management are disarticulation at hip level or above knee level.

The most common application of treatment with total femoral endoprosthesis is for the management of primary or secondary oncological femoral involvement. The most frequent location of primary or secondary involvement in the appendicular skeleton takes place in the femur. Lesions include sarcoma, chondrosarcoma, undifferentiated pleomorphic sarcoma, and bone metastases.[4] Doctor Pan and his group reported the use of total femur endoprosthesis in considerable volume sarcomas with a mean follow-up of 27 months. Due to the neoplastic disease, six patients died during the follow-up, reflecting the severity of the underlying illness that indicated this procedure.[5] Muratori et al reported 32 total femur replacements between 2002 and 2018, and they found 87% revision implant-free survival of the implants at 5 and 10 years, and 72% at 15 years. Overall implant survival of the prosthesis was 90% at 15 years.[6]

Total femur replacement is also helpful in situations unrelated to oncological problems.[7] Since total hip and knee replacements have risen, complications secondary to these procedures have also increased.[8,9] Among these, aseptic loosening, infection, and periprosthetic fractures can lead to multiple revision procedures, with subsequent bone loss and the need for increasing implant size.[10,11] In addition, its use has been reported in failed proximal or distal femur replacement.[12] Finally, total femur replacement is essential in patients with multiple revision surgeries and extensive femoral bone loss that makes their approach impossible by conventional methods.[3]

Furthermore, it's useful for comminuted periprosthetic fractures with a high rate of failure and complications of osteosynthesis.[12] These patients have undergone multiple surgeries, and there is a marked deterioration in the baseline state, soft tissues, and bone quality, which makes them more susceptible to complications and technical difficulties during surgery.[7] Dr. Toepfer's group has a series of 22 patients treated with total femur replacement for non-oncological reasons with an average follow-up of 63 months. Overall failure rate was 59.1%, leading to 38 surgical revisions. The most common failure mechanisms were soft tissue, infection, and mechanical failure.[13]

Finally, this procedure has other less frequent indications: patients with periprosthetic pathological fractures in Paget's disease, and massive pseudotumors of the femur in patients with hemophilia.[3,14]

PERIOPERATIVE CONSIDERATIONS

The first thing to keep in mind when planning this procedure is the type of patient. As mentioned in the previous section, they usually have a history of cancer, infections, or multiple interventions that decrease their functional reserve and weaken them.[3] In addition, these patients are generally in chemotherapy or radiation therapy, so it is necessary to inquire about the specific side effects of each chemotherapy, as cardiotoxic effects are common. In addition, another common side effect of chemotherapy is bone marrow suppression, which can cause anemia. Therefore, in scheduled orthopedic surgeries, it is crucial to ensure that hemoglobin levels are above 12 mg/dL for women and 13 mg/dL for men. Similarly, it is essential to determine whether patients have undergone radiation therapy, especially in the chest, due to the high risk of developing pulmonary fibrosis.[15]

It is important to note that total femur replacement is an intervention that involves a long surgical time with the inherent risk of surgical wound contamination. In addition, a broad dissection of the soft tissues could favor devitalization and increase the risk of infection.[16]

As noted earlier, comorbidities in patients undergoing total femur replacement are essential. Cancer itself and orthopedic surgery are independent risk factors for deep venous thrombosis.[15] Bone tumors (compared with soft tissue tumors) and patients undergoing prosthetic reconstruction represent additional risk factors among these patients. Moreover, the incidence of pulmonary embolism in cancer patients undergoing surgery ranges between 0,6% and 11%.[15] That said, mechanical and pharmacological prophylaxis is vital in the perioperative setting. Rates of pulmonary embolism in patients with a combination of mechanical (when possible) and pharmacological prophylaxis reduced to 0.6% to 1%.[15]

Both the surgical time and the extension of the approach produce considerable bleeding that must be taken into account during the planning and execution of the surgery to take measures to counteract the patient's anemia, for example, multiple blood transfusions and the use of cell salvage devices.[17] In cancer surgery, cell salvage has historically been avoided because of concerns about potentially spreading tumor cells back into the patient. However, it is essential to note that this concern is hypothetical and lacks evidence.[15] Other ways to prevent perioperative bleeding include the use of antifibrinolytic agents. It has been demonstrated that their use reduces bleeding without increasing the risk of thrombotic events.[15]

The factors mentioned above imply the need to book an intensive care unit bed for immediate postoperative care, where hemodynamic parameters can be better controlled and, if needed, life support will be guaranteed.[3]

It is worth emphasizing that the surgeon must take into account the possible presence of acetabular defects in the context of an oncology patient or revision. Multiple methods exist to address this problem, such as bone grafts, jumbo cups, trabecular metal augments, or acetabular reconstruction rings.[18]

The extensive dissection of soft tissues and muscle attachments involved in the surgical technique makes the construct inherently unstable. Therefore, it is important to use strategies to reduce the risk of dislocation of the femoral head, such as dual mobility cups, and in the knee, the use of constrained hinge-type components.[19,20]

DESIGNS

The first available designs are the conventional endoprosthesis that behave as a fixed system, where the proximal segment corresponding to the hip is continued to the knee (Figure 1).[3] The usual length of these implants varies between 280 mm-570 mm. A significant advantage of this system lies in its modularity, which allows you to play with the length and the femoral version proximally- the length is modifiable in 10 mm increments. In addition, fixed or mobile polyethylene inlay tibia has modular augments, stems, and offset adapters that can be used in the knee.[21] Finally, in the proximal segment, the prostheses have slots that allow muscle reinsertion of the hip abductors.[3]

Figure 1: Implantcast. MUTARS® total femoral replacement MK. Implantcast. EDM Colombia. Available at: https://www.implantcast.de/en/for-medical-professionals/products/standard-/-tumour-prosthetics/pelvis-and-hip-endoprosthetics/revision-and-tumour-endoprosthetics/mutarsr-total-femoral-replacement-mk/.

The second alternative is the "Durchsteck"-or push-through-total femoral endoprosthesis, which consists of an intramedullary prosthesis based on the union of previously implanted femoral components of hip and knee arthroplasties. Custom-made intramedullary nails or an intercalary segment connecting both prostheses is practical because it allows the preservation of any remaining femoral cortex and muscle attachments. The main advantages of this design are preserving bone stock and less soft tissue dissection, reducing bleeding, and preserving muscle insertions that reflect instability.[22] Gorter and his group reported ten patients treated by push-through total femoral endoprosthesis with a mean follow-up of 5.3 years. This series reported four complications, two infections, and two mechanical failures. However, at the end of the follow-up, patient survival was 100%, limb survival 90%, and prosthesis survival 80%.[23]

The vast majority of patients will have acetabular defects secondary to tumor resection, osteolysis, or secondary to multiple revisions. Therefore, unique implants may be helpful to treat these defects, such as reconstruction rings, trabecular metal wedges, allografts, or custom implants.[19] Additionally, it is essential to remember that due to severe muscle deficiency, especially in the gluteus medius, bipolar or double mobility acetabular cups should be used to reduce the risk of instability.[24] Because of the severe bone and soft tissue loss, a highly constrained knee articulation is mandatory. Rotating the hinge is necessary for global instability around the knee. The main disadvantages of hinges are the high degree of loosening secondary to increased forces between the interface and the prosthesis since it only allows mobility in one plane. Using rotating hinges has reduced loosening by having a load transmission slightly more similar to the anatomical. The survival rate in patients with total femur replacement and the rotating hinge is 79.6% at one year and 68.2% at five years.[25]

SURGICAL TECHNIQUE

The proper execution of the procedure begins with the positioning of the patient in lateral decubitus on a conventional table. Different approaches in the literature include an extended lateral approach to the knee, allowing total exposure of the femur and proximal tibia (Figure 2). This technique facilitates visualization of the structures and manipulation of the stent. However, its main disadvantage lies in the more significant dissection of soft tissues with the consequent bleeding.[23]

Figure 2: Sharma R- intra-operative image of a lateral approach extended to the knee with a total femoral endoprosthesis already positioned.

On the other hand, one could carry out a lateral approach to the proximal femur and the middle third and independently carry out an anterior approach to the knee that allows working on the distal femur and proximal tibia. The main advantage lies in less soft tissue dissection and bleeding.[26] With the posterolateral approach completed in the hip, the dissection must be done carefully since, in general, there is a lot of fibrosis and normal anatomy is altered on the way to the joint. Depending on the cause leading to the procedure, resection of the proximal femur tumor and removal of prosthetic components or cement spacers are performed.[23] Finally, the preparation of the acetabulum and positioning of the trial and final acetabular cup is performed.[3] Once completed, a circumferential dissection of the femur's muscular and soft tissue attachments follows, with particular attention to the neurovascular structures. The dissection must extend toward the distal femur when having a single incision. In case of having two independent incisions, approximation must be through the knee. All anterior, posterior, medial, and lateral muscle attachments should be dissected with particular care in the structures around the popliteal fossa.[26] The surgical piece is then removed from the femur, and the tibial component preparation begins. Surgeons should take special care with patella excursion secondary to the component's external rotation.[3] Once the definitive tibial plateau is ready, the assembly of the femur begins to test its length and the tension of the soft tissues. The femoral stems have different magnifications to play with and find the ideal length for the patient's extremity.[26] The femoral version can be modified proximally. Once the indicated size is confirmed, the positioning of the final femoral component follows. Then, an evaluation of hip stability maneuvers and patella excursion is necessary to guarantee functionality-finally, regular wash out with saline and hemostasis. Next, the remaining gluteal and vastus lateralis muscles must be reinserted into the proximal slots of the stem. Ultimately, layered closure achieves coverage of the femoral component with the thigh musculature, the subcutaneous cellular tissue, and the skin. Given the ample dead space, the use of a drain for a few days is recommended.[23,26]

REHABILITATION

Although it is an extensive surgery, the patient can perform immediate mobility. In general, postoperative evaluation occurs in the intensive care unit; once their general condition stabilizes, the patient can start walking and begin with support to tolerance.[27] Establishing protocols emphasizing strengthening of the quadriceps and the abductor mechanism is necessary. The patient will also need an abductor brace for six weeks.[28]

CLINICAL AND FUNCTIONAL RESULTS

Since this is not a frequent procedure, the literature support relies on case series. For example, in 2012, McLean reported a score of 68 on the Toronto extremity salvage score and 53 on the short form 36 in 20 patients undergoing total femur replacement for a periprosthetic fracture.[29] The group from the technical university of Munich reports a function between 1 and 15 with an average of 10±4 out of 30, according to the Enneking functional evaluation method (MSTS-score).[30] More recently, the Putman group, in their series of 29 total femur replacements for non-oncological reasons with a 6-year follow-up, shows that 51.7% of the patients achieve independent walking, 41.3% achieve walking with a cane, and only 6.89% of patients fail to return to walking.[31] In 2022 Yang et al reported the case of a patient treated with total femur replacement with 18 years to follow up. The patient has standard functionality and no evidence of recurrence, metastasis, prosthesis loosening, dislocation, fracture, or other complications.[32]

COMPLICATIONS

Traditionally, total femur replacement has been considered a procedure with a high risk of complications, given its surgical complexity and magnitude.[33] Nevertheless, in one of the most extensive series available, Medellin and the Birmingham group report the following complications: infection at 18%, structural failures at 6%, tumor progression at 5%, aseptic loosening at 2%, and soft tissue failures at 1%. Additionally, they found that the factors associated with failure were a history of multiple previous surgeries (hazard index (HR) 3.7; p=0.041) and associated arthroplasty of the proximal tibia (HR 3.8; p=0.034).[33]

SURVIVAL

The evidence regarding survival is conflicting and varies depending on each series. In the worst scenarios, the failure rate reaches 72% in an average follow-up of 80 months.[29] The most favorable scenarios show an average survival of 70% at ten years.[30] Specifically, patients with oncological pathology have survival rates of 71% at five years, 63% at ten years, and 3.7% at fifteen years.[13]

CONCLUSION

Total femur replacement is a procedure performed in extreme cases with oncological and non-oncological pathologies that compromise the viability of the limb. The literature comes mainly from case series, given its low frequency and yet space for implementation. It has particular and essential perioperative considerations and is a highly demanding surgical technique. Nevertheless, despite the high rate of complications, in some cases, it is the only option to preserve limb function and improve the patient's quality of life.

ACKNOWLEDGEMENTS

The authors would like to thank EDM, Implantcast representative in Colombia and Dr. Rajeev K. Sharma Chairman, institute of orthopaedics joint replacement, sports medicine, and trauma Moolchand Medcity, Lajpat Nagar, New Delhi, India for their contribution in providing the pictures for this review.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Not required

REFERENCES

1. Buchman J. Total femur and knee joint replacement with a vitallium endoprosthesis. Bull Hosp Joint Dis. 1965;26:21-34.
2. Berend KR, Lombardi AV, Mallory TH, Adams JB, Dodds KL. Total Femoral Arthroplasty for Salvage of End-stage Prosthetic Disease. Clin Orthop Relat Res. 2004;427:162-70.
3. Ramanathan D, Siqueira MBP, Klika AK, Higuera CA, Barsoum WK, Joyce MJ. Current concepts in total femoral replacement. World J Orthop. 2015;6(11):919-26.
4. Sewell MD, Spiegelberg BGI, Hanna SA, Aston WJS, Bartlett W, Blunn GW et al. Total femoral endoprosthetic replacement following excision of

bone tumours. J Bone Joint Surg Br. 2009;91(11):1513-20.
5. KL P, WH C, P S, GB O, F K, S T. Large Volume Osteosarcomas of the Femur Treated with Total Femoral Replacement. Malays Orthop J. 2014;8(1):32-6.
6. Muratori F, Mondanelli N, Prifti X, Scoccianti G, Roselli G, Frenos F et al. Total femur prosthesis in oncological and not oncological series. Survival and failures. J Orthop. 2020;17:215-20.
7. Luengo-Alonso G, Moreno-Beamud JA, Delgado-Díaz E. Total femur prosthesis in non-oncological patients. Acta Ortop Mex. 2021;35(2):188-92.
8. Kelmer G, Stone AH, Turcotte J, King PJ. Reasons for Revision: Primary Total Hip Arthroplasty Mechanisms of Failure. J Am Academy Orthop Surgeons. 2021;29(2):78-87.
9. Le DH, Goodman SB, Maloney WJ, Huddleston JI. Current Modes of Failure in TKA: Infection, Instability, and Stiffness Predominate. Clin Orthop Relat Res. 2014;472(7):2197-200.
10. Sakellariou VI. Management bone loss of the proximal femur in revision hip arthroplasty: Update on reconstructive options. World J Orthop. 2014;5(5):614.
11. Mancuso F, Beltrame A, Colombo E, Miani E, Bassini F. Management of metaphyseal bone loss in revision knee arthroplasty. Acta Biomed. 2017;88(2S):98-111.
12. Ward WG, Dorey F, Eckardt JJ. Total femoral endoprosthetic reconstruction. Clin Orthop Relat Res. 1995;(316):195-206.
13. Toepfer A, Harrasser N, Petzschner I, Pohlig F, Lenze U, Gerdesmeyer L et al. Is total femoral replacement for non-oncologic and oncologic indications a safe procedure in limb preservation surgery? A single center experience of 22 cases. Eur J Med Res. 2018;23(1):5.
14. Clement ND, MacDonald D, Ahmed I, Patton JT, Howie CR. Total Femoral Replacement for Salvage of Periprosthetic Fractures. Orthopedics. 2014;37(9).
15. Karmaniolou I, Makris A, Lamprou K, Staikou C. Perioperative management of patients with bone and soft tissue tumors: A narrative review. Acta Anaesthesiol Belg. 2017;68:1-12.
16. Buchowski JM, Cascio BM, Streiff MB, Frassica FJ. Resection and Reconstruction of a Massive Femoral Hemophilic Pseudotumor. Clin Orthop Relat Res. 2005;430:237-42.
17. Fountain JR, Dalby-Ball J, Carroll FA, Stockley I. The Use of Total Femoral Arthroplasty as a Limb Salvage Procedure. J Arthroplasty. 2007;22(5):663-9.
18. Ashworth A, Klein AA. Cell salvage as part of a blood conservation strategy in anaesthesia. Br J Anaesth. 2010;105(4):401-16.
19. Ahmad AQ, Schwarzkopf R. Clinical evaluation and surgical options in acetabular reconstruction: A literature review. J Orthop. 2015;12:S238-43.
20. Ko LM, Hozack WJ. The dual mobility cup. Bone Joint J. 2016;98-B(1-A):60-3.
21. Gebert C, Wessling M, Götze C, Gosheger G, Hardes J. The Modular Universal Tumour And Revision System (MUTARS®) in endoprosthetic revision surgery. Int Orthop. 2010;34(8):1261-5.
22. Peters CL, Hickman JM, Erickson J, Lombardi AV, Berend KR, Mallory TH. Intramedullary Total Femoral Replacement for Salvage of the Compromised Femur Associated With Hip and Knee Arthroplasty. J Arthroplasty. 2006;21(1):53-8.
23. Gorter J, Ploegmakers JJW, ten Have BLEF, Schreuder HWB, Jutte PC. The push-through total femoral prosthesis offers a functional alternative to total femoral replacement: a case series. Int Orthop. 2017;41(11):2237-44.
24. Vajapey SP, Fideler KL, Lynch D, Li M. Use of dual mobility components in total hip arthroplasty: Indications and outcomes. J Clin Orthop Trauma. 2020;11:S760-5.
25. Pour AE, Parvizi J, Slenker N, Purtill JJ, Sharkey PF. Rotating Hinged Total Knee Replacement. J Bone Joint Surg. 2007;89(8):1735-41.
26. Ahmed AR. Total femur replacement. Arch Orthop Trauma Surg. 2010;130(2):171-6.
27. Agrawal A, Agrawal V, Yadav S, Soni SK, Pawar SK. A Case Report of Dual Incision Technique for Total Femur Arthroplasty as a Salvage Procedure in Infected Non-Unions. J Orthop Case Rep. 2017;7(4):44-7.
28. Hwang JS, Beebe KS, Patterson FR, Benevenia J. Infected Total Femoral Replacements: Evaluation of Limb Loss Risk Factors. Orthopedics. 2011;34(11).
29. Jones KB, Griffin AM, Chandrasekar CR, Biau D, Babinet A, Deheshi B, et al. Patient-oriented functional results of total femoral endoprosthetic reconstruction following oncologic resection. J Surg Oncol. 2011;104(6):561-5.
30. McLean AL, Patton JT, Moran M. Femoral replacement for salvage of periprosthetic fracture around a total hip replacement. Injury. 2012;43(7):1166-9.
31. Toepfer A, Harrasser N, Petzschner I, Pohlig F, Lenze U, Gerdesmeyer L et al. Short- to long-term follow-up of total femoral replacement in non-oncologic patients. BMC Musculoskelet Disord. 2016;17(1):498.
32. Yang YH, Chen JX, Chen QY, Wang Y, Zhou YB, Wang HW et al. Total femur replacement with 18 years of follow-up: A case report. World J Clin Cases. 2022;10(15):4957-63.
33. Putman S, Migaud H, Saragaglia D, Jenny JY, Dujardin F, Hue AG et al. Total femur replacement in non-oncologic indications: Functional and radiological outcomes from a French survey with a mean 6 years' follow-up. Orthop Traumatol Surg Res. 2019;105(4):591-8.

Cite this article as: Gaitán-Lee H, Peña S, Suárez LJ, Guzmán F, Piñeros M. Total femoral replacement: a challenging but promising limb salvage option. Int J Res Orthop 2023;9:844-8.