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Physical therapy following hip and knee tumoral prosthesis and total femur replacement revision surgery for bone sarcoma, a case report

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Abstract

Introduction: Background and Purpose: Bone sarcomas are rare malignant bone tumors, and large lesions often necessitate complex Limb-Salvage Surgery (LSS), such as Total Femur Replacement (TFR). While LSS is the standard of care, there is a paucity of detailed, evidence-based rehabilitation protocols, especially for patients undergoing extensive, multi-joint reconstructions. This case report aims to document the effect of a structured, early post-operative physical rehabilitation program in a patient who underwent TFR for extensive femoral sarcoma. **Case presentation:** A 54-year-old male with recurrent osteosarcoma and multiple prior surgeries underwent a revision Total Hip and Knee Replacement with TFR. Six weeks post-surgery, the initial assessment revealed severe pain (visual analog scale: 6), major limitations in Range of Motion (ROM) (e.g., knee flexion 30∘), and severe muscle weakness (manual muscle testing (MMT: 1 in most muscles). **Outcomes:** The patient underwent a 20-session structured rehabilitation program focusing on pain management (High-Frequency TENS), early ROM recovery (Continuous Passive Motion (CPM)), and progressive strengthening. After 20 sessions, the patient achieved a significant pain reduction to VAS: 2 and significant ROM recovery, including 90∘ of knee and hip flexion. Functional progress was seen as the patient moved from a partial weight-bearing walker to walking with a single cane. The primary residual challenge was severe knee extensor (quadriceps) weakness (MMT: 2), causing the knee to "give way". **Conclusion:** This case demonstrates that a structured and progressive early rehabilitation protocol is highly effective in achieving rapid pain control and significant recovery of joint range of motion following complex TFR. The persistence of severe quadriceps weakness is a known challenge that requires targeted intervention.

Keywords: rehabilitation, Physical therapy, Bone tumor, Prosthesis, Total femur replacement, Hip arthroplasty, knee arthroplasty

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Introduction

Bone sarcomas are rare primary malignant mesenchymal bone tumors. The three main entities are osteosarcoma, chondrosarcoma, and Ewing sarcoma. While prognosis has improved for affected patients over the past decades, bone sarcomas are still critical conditions that require an interdisciplinary diagnostic and therapeutic approach (1). The femur is one of the most frequent sites for bone sarcomas. When the tumor involves a large segment of the femur, a less conventional approach is required to eradicate the tumor (2). Total femur resection has been proposed for extensive bone destruction (3). This procedure is technically demanding and needs detailed preoperative planning and careful reconstruction.

Reconstructive options after total resection include a total femur allograft or a total femur prosthesis (2, 4). In the past, amputation was considered the main treatment for bone and soft tissue sarcomas. However, with significant advances in limb-salvage surgery (LSS) and adjuvant therapies such as chemotherapy and radiotherapy, this approach has changed (1, 5). Today, limb-salvage surgery has become a standard treatment, and in approximately 90% of cases, it is possible to preserve the limb (5, 6). LSS is considered to be less invasive, provides better function and quality of life than amputation (7). Nevertheless, LSS, unlike amputation, is associated with more perioperative complications, prolonged hospital stays and requires repeated surgeries due to various reasons such as infection and prosthetic failure. LSS demands high surgical skills, whereas amputation is a simple surgical procedure. Additionally, recent progress in prosthetic limbs, for example, microprocessor-based joints and endoskeletal prosthetic reconstructions, has improved the functional outcome and cosmetic outlook following amputation (7).

Early physical rehabilitation is the key to achieving a good functional outcome and quality of life after LSS but rehabilitation techniques following LSS are largely neither tested nor documented in detail (8). The most accepted rehabilitation technique for these patients, once the surgery is performed, remains conjectural and is largely untested (6).

Rehabilitation after limb-salvage surgery is a complex process with protocols that vary depending on the type of surgery and the location of the lesion (5). The primary goal of rehabilitation following tumoral prosthesis surgery is to maximize functional recovery and improve patient mobility (5, 9). Early and structured rehabilitation, especially after tumoral knee prosthesis replacement, significantly improves gait symmetry, walking speed, and balance control in patients (9). Timely and individualized exercise in standard postoperative care can help improve mobility (9). Some studies show that a standardized rehabilitation protocol after limb-salvage surgery for sarcomas can improve patient outcomes (6). Early Mobilization for patients with a proximal femur megaprosthesis (10) Early weight-bearing, especially in patients with distal femur tumoral prostheses, is considered part of a standard rehabilitation protocol (11).

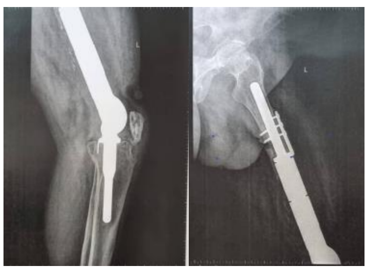
"Based on studies conducted in the field of rehabilitation following megaprosthesis surgeries for femoral bone sarcoma, it is observed that there has not been much research, and the effect of rehabilitation on these patients has not been accurately investigated. Given that the post-operative rehabilitation program depends on the surgical site and the extent of bone and soft tissue damage in the area affected by sarcoma, existing studies have usually examined rehabilitation programs after surgeries limited to a single region (distal femur, proximal femur, etc.). No study examines the effect of post-operative rehabilitation for sarcoma that involves a vast area (hip, femur, and knee). Our goal is to investigate the effect of rehabilitation in a patient with extensive sarcoma who has undergone hip joint replacement, total femoral replacement, and knee joint replacement."

Case presentation:

Following a thorough explanation of the treatment, the patient fully consented to enter the study. The patient is a 50-year-old male who developed osteosarcoma in the distal femur at the age of 29. At age 30, he underwent his first bone graft, a 30 cm segment to the distal femur, along with chemotherapy. Two years later, a fracture occurred in the grafted bone due to a fall, necessitating a second graft. The second bone graft was unsuccessful, leading to rejection and infection. As a result, the graft was removed, and three 3-month stages of cementation were performed.

Afterward, the cement was removed, and a total knee replacement was performed (Figure 1).

(a)



(b)

(c)

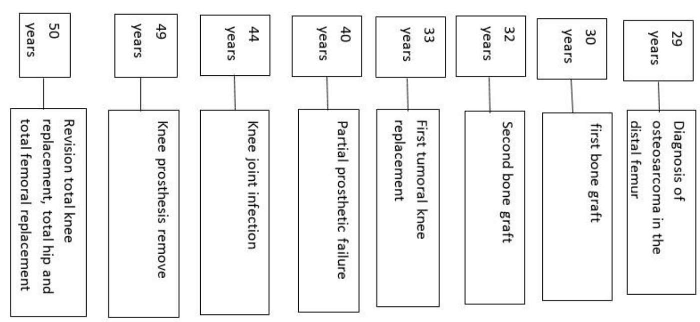
Figure 1: X-ray view of primary joint knee replacement. (a). anteroposterior view X-ray (b). Lateral view X-ray (c). scanogram X-ray

Seven years after the knee replacement, the prosthesis was slightly damaged in an accident, and the patient was forced to use two crutches to walk. He could no longer fully straighten his knee, walking with a bent knee and on his tiptoes. Approximately 11 years after the knee replacement, the patient developed a knee infection, experiencing severe pain and swelling. He was treated with antibiotics. Finally, 16 years after the knee replacement surgery, the prosthesis was removed, and the patient underwent 9 months of cementation and debridement in three 3-month stages. After the infection was controlled, the patient underwent a tumor prosthesis surgery of the hip and knee, with a complete replacement of the femur (Figure 2).

(a)

(b)

Figure 2: Revision hip and knee joint and femur replacement. (a) .Lateral view X-ray (b). Anteroposterior view X-ray



Post-Surgical Rehabilitation

Twenty-four hours after the surgery, the patient was seen by a physical therapist. He was taught how to move in bed, sit (Avoid excessive knee and hip flexion, and refrain from hip adduction and internal rotation), and walk with an assistive device. He was instructed to walk with a walker and to use partial weight-bearing. He was also taught isometric exercises for the gluteal, quadriceps, adductor, and abdominal muscles (perform exercises 3 times daily, with 20 repetitions per set). For isometric exercises, use a 10-second contraction followed by a 10-second rest and was advised to use an ice pack to reduce pain and swelling. Per the surgeon's recommendation and considering the type of surgery and tissue repair performed, the patient is to commence physical therapy at a rehabilitation clinic six weeks post-operation. The patient was discharged from the hospital after a 10-day stay. One month after the surgery, the patient developed a discharge from the surgical site, and the wound was opened and irrigated. Six weeks after the second knee and hip replacement, the patient was referred to a rehabilitation center.

Initial Assessment at Rehabilitation Center

After the initial evaluation at the physical therapy center, a treatment plan was created. The assessment included: range of motion (ROM) of the ankle, knee, and hip joints, lower extremity muscle strength, pain assessment, and lower extremity nerve evaluation. The lower extremity nerves were found to be without issues (sensory and motor evaluation). The neurological examination was carried out manually by an expert physiotherapist. The patient reported severe pain (visual analog scale VAS: 6). The assessment of the patient's ROM and muscle strength was as follows: Ankle: Active dorsiflexion was absent (MMT: 1), and passive ROM was limited (dorsiflexion: 10°). He had a tight Achilles tendon. Active plantarflexion was present but weak (MMT: 3), while passive ROM was full. Active knee flexion was absent (MMT: 1), and passive ROM was limited (flexion: 30°). Active extension was absent (MMT: 1), and passive ROM was limited (extension: 10°). Hip: Active flexion was absent (MMT: 1), and passive ROM was limited (flexion: 20°). Active extension was weak (MMT: 2), and passive ROM was limited (extension 20°). Active abduction was absent (MMT: 1), and passive ROM was limited (abduction: 10°). Active adduction was absent (MMT: 1), and passive ROM was 0°. Active external rotation was weak (MMT: 2), and passive ROM was limited (20°). Active internal rotation was weak (MMT: 1), and passive ROM was limited (internal rotation: 10°). A skilled physical therapist manually assessed muscle strength and evaluated the range of motion using a goniometer. The patient was walking with a walker, using partial weight-bearing.

Treatment Plan and Progress

The treatment plan was designed to reduce pain, improve walking with an assistive device, increase joint range of motion, strengthen lower extremity muscles, and improve balance and quality of life. The patient was told to attend the physical therapy center three times a week for 20 sessions (The patient was told to perform the exercises at home 2 times a day with 20 repetitions each time). The patient was instructed to ambulate using two crutches with weight-bearing as tolerated on the surgical leg. High-frequency TENS was used on the thigh, knee, and calf for 15 minutes in two stages to reduce pain (4 electrodes on the thigh for 15 minutes, and 4 electrodes on the knee and calf for 15 minutes). Active-assistive ankle pump exercises for increasing ankle ROM were started using a resistance band under the foot, which the patient pulled with his hands. After about 10 sessions, the patient was able to actively dorsiflex his ankle and the exercises were progressed to active and then resisted, and standing exercises were also added to the patient's exercise program. A Continuous Passive Motion (CPM) machine was used for 10 sessions to increase knee and hip ROM (30 minutes per session, starting from 10°-60° and progressing to 0°-90°). After 10 sessions, active-assistive exercises for knee and hip ROM were initiated using a therapy ball and a frame, and springs. In the final sessions, the patient was able to actively flex his knee and hip and standing exercises were also added to the patient's exercise program. Hip abduction, adduction, and internal/external rotation were started with active-assistive exercises using the frame and springs. In the final sessions, these exercises were progressed to active exercises performed in a side-lying position on the unaffected side. In approximately the last 5 out of 20 sessions, balance exercises utilizing a wobble board, stepping exercises, and gait training were added to the patient's rehabilitation program. In total, exercises were progressed from easy to difficult according to the patient's ability, starting with active-assisted exercises, progressing to active, and then to resisted exercises. The positions typically progressed from supine (lying on the back) on the treatment table to side-lying, and then to sitting and standing.

Re-evaluation After 20 Sessions

The patient was re-evaluated after 20 sessions. Ankle: Active and passive ROM for dorsiflexion and plantarflexion were full. MMT evaluation showed dorsiflexors and plantar flexors were grade 4. Knee: Active and passive flexion ROM was 90°. Passive knee extension was full, but active extension was limited due to extensor weakness. MMT evaluation showed knee flexors were grade 3 and extensors were grade 2. Hip: Active and passive hip flexion ROM was 90°. Passive ROM for extension, abduction, adduction, external rotation, and internal rotation was full. Active ROM for abduction, adduction, and internal rotation was limited due to muscle weakness. MMT evaluation showed hip flexors were grade 3, extensors and external rotators were grade 4, and abductors, adductors, and internal rotators were grade 2. Pain: The patient's pain was a VAS: 2. Gait: The patient was able to walk with one cane, but due to the weakness of the knee extensor muscles, he occasionally complained of the knee "giving way" while walking, and was advised to use a knee brace.

Discussion

The main goal of Limb Salvage Surgery (LSS) in orthopedic oncology is to preserve optimal functional outcomes and improve the patient's long-term quality of life (8) and based on current evidence, endoprosthetic reconstructions in the femoral area are accepted as a common and standard procedure (12). In this present case was a complex reconstruction, such as a distal femur megaprosthesis (5). It is worth noting that studies have shown that the standardization of rehabilitation protocols following sarcoma surgeries significantly improves patients' functional outcomes (6). The data from this case study demonstrate the effectiveness of a structured and progressive rehabilitation protocol in the rapid recovery of ROM and the reduction of pain levels in the initial post-operative stages.

Rapid Recovery of Range of Motion and Pain Management

The patient's initial condition, characterized by severe pain (VAS: 6) and major limitations in all lower limb joints, especially the knee (flexion: 30∘) and ankle (dorsiflexion: 10∘), represented a significant challenge. This high level of motion restriction and muscle weakness (MMT: 1 in most muscles) is entirely expected in cases requiring procedures like Total Femur Replacement (TFR), which is performed due to the tumor's size and is a highly challenging surgery (13). The significant reduction in pain to VAS: 2 within 10 sessions, which was achieved with the use of high-frequency TENS, fast patient tracking and training, indicates that early and effective pain management is a critical prerequisite for successfully initiating active exercises (11).

The complete recovery of ankle ROM and the significant improvement in knee and hip ROM to 90∘ of flexion, achieved through the combined use of CPM and active-assistive exercises, underscore the importance of early and aggressive mechanical interventions (11). The use of CPM, especially in knee megaprosthesis reconstructions, is an accepted method for preventing joint fibrosis and increasing ROM (11). After achieving the initial ROM goals, the successful transition of exercises to the active-assistive phase and then to progressive resistance training in functional positions (such as side-lying for hip muscles) demonstrated a logical and successful treatment progression, leading to an improvement in ankle muscle strength to Grade 4.

The Challenge of Quadriceps Weakness and Gait

Despite the significant progress, the main challenge identified in the 20-session evaluation was the remaining severe weakness in the knee extensor muscles (quadriceps) with a grade of MMT 2. This weakness, which resulted in the patient's complaint of "Knee Giving Way" and the recommendation for a knee brace, is a common and known complication following limb salvage surgeries in the distal femur area (7). Studies emphasize that quadriceps weakness after endoprosthetic knee reconstruction is often the primary factor in long-term gait abnormalities and reduced functional mobility (14). This weakness is caused by muscle detachment, denervation, or displacement of the patellar tendon insertion site during surgery (14).

The patient’s successful progression in their walking pattern, from a partial weight-bearing walker to a single cane, indicates an overall improvement in trunk stability and lower limb control (9). However, the inability to reach MMT 3 for the knee extensors at this stage necessitates a special focus on targeted quadriceps strengthening in the remaining sessions (7). Functional outcomes after extensive lower limb reconstructions, even in the best cases, are often at a compromised level, although they remain functionally superior to amputation (15). Implementing rehabilitation protocols that focus on neuromuscular activation and quadriceps strengthening through closed-chain exercises and isometric exercises is crucial for improving stability during the stance phase of gait and eliminating reliance on the brace (9). Continued monitoring and fine-tuning of the rehabilitation protocol, as recommended by systematic studies, are essential for achieving the maximum functional outcome after sarcoma surgeries (5). In the studied patient, the primary focus was placed on strengthening lower limb muscles and restoring the range of motion in the lower limb joints. Work was also done to improve the patient's gait quality.

Future studies can utilize other rehabilitation methods in these patients and investigate the effects of different treatments on lower limb strength, quality of life, and other parameters. Furthermore, to confirm the therapeutic effects observed in our case study, a larger patient population needs to be studied. Furthermore, a longer follow-up period is needed to adequately assess the treatment effects.

Conclusion

This case demonstrates that a structured and progressive early rehabilitation protocol is highly effective in achieving rapid pain control and significant recovery of joint range of motion following complex TFR. The persistence of severe quadriceps weakness is a known challenge that requires targeted intervention.

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Ethical consideration

This article was a case report, and we provided consent words from the participants.

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Conflict of interest

None.

Authors' contributions

All authors contributed equally to the preparation of this article.

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