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Physical Therapy Interventions for Post-Operative Giant Cell Tumor of the Distal Femur: A Case Report

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ABSTRACT

Background: Giant cell tumor (GCT) is a relatively rare type of primary benign bone tumor, characterized by multinucleated giant cells resembling osteoclasts. Treatment of GCT with intralesional resection and bone cement filling, especially in tumors that develop around the knee joint. After GCT surgery around the knee joint, in general, patients will experience several symptoms such as pain in the operating area and surrounding structures, limited range of motion, then symptoms that are quite worrying, namely related to the ability of knee function in the future. The role of physiotherapy after GCT surgery around the knee joint, especially the distal anterolateral part of the femur, was stated to be able to restore the functional ability of the knee without limitations.

Case Description: A 24-year-old male employee of the laboratory analysis division of Udayana University Hospital was diagnosed with GCT in the distal right femur. The diagnosis was made on September 30, 2021, using a biopsy with bone, joint, and articular cartilage specimens of the distal right femur. The patient underwent intralesional resection surgery, bone cement filling, and internal fixation of the distal femur in November 2021. Postoperatively the patient complained of pain in the posterior and medial distal right thigh, as well as limitations when bending the right knee. In addition, the patient also admitted to having difficulty doing squat movements.

Conclusion: Patients experienced an improvement in their symptoms after carrying out seven physiotherapy sessions for 3 weeks. However, the patient still needs further exercise so that the walking pattern can show better development.

Keywords: Giant cell tumor, femur, physical therapy, post operative, rehabilitation

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Introduction

Giant cell tumor (GCT) is a relatively rare type of primary benign bone tumor, characterized by multinucleated giant cells resembling osteoclasts. Although it is a benign tumor, GCT is locally aggressive and has the potential to become a metastatic malignant tumor. GCT is generally found in the epiphysis and metaphysis of long bones (75%-90%), especially in the bones around the knee joint (50%-65%), such as the distal femur or proximal tibia. However, GCT can also develop in other bones such as the distal radius, proximal humerus, or proximal femur.[1,2]

GCT is also a widely discussed type of bone tumor. The prevalence of GCT is recorded at 3%-8% in western countries and 20% in Asia of the total primary bone tumors, where 80% of cases are in the age range of 20-50 years, with a peak of patients in the third decade of life. GCT also has a high risk of recurrence at 10%-65%, even though studies have been conducted to treat tumors. In addition, 10% of GCTs can develop into malignant tumors.[2,3]

GCTs can be grouped based on the Enneking system. Stage 1 (T0) benign bone tumors are characterized by latent lesions that are biologically static, stage 2 (T1) is an active lesion that grows slowly and is confined to the bone only, and stage 3 (T2) is a localized aggressive lesion with extension to the soft tissue surrounding the lesion.[3] In terms of clinical symptoms, patients with GCT generally experience pain due to bone destruction by the tumor. Tumors that develop near the joints can decrease the range of motion (ROM), joint effusion, and synovitis. A soft tissue mass or lump will be seen if the GCT extends beyond the bone. In addition, 11%-37% of GCTs result in pathological fractures.[4,5]

Treatment of GCT with intralesional resection and cement filling, especially in tumors that develop around the knee joint, has shown satisfactory results. Bone cement filling after tumor removal does not increase the risk of tumor regrowth and does not trigger the occurrence of osteoarthritis while maintaining the continuity of the articular cartilage.[6] After GCT surgery around the knee joint, patients generally will experience several symptoms such as pain in the operating area and surrounding structures, limitation of ROM, and past symptoms that are quite worrying are related to the ability to function in the future.[1,7] The role of physiotherapy around GCT surgery around the knee, especially the distal anterolateral part of the femur, is stated to be able to restore the ability of the knee without limitations.[8]

Case report

A 24-year-old male laboratory analyst at Udayana University Hospital was diagnosed with GCT in the distal right femur. The diagnosis was made on September 30, 2021, using a biopsy of the distal right femur's bone, joint, and articular cartilage specimens. The patient underwent intralesional resection surgery, bone cement filling, and distal femur internal fixation in November 2021. Postoperative x-ray imaging test results are shown in **Figure 1**. After surgery, the patient had several physiotherapy sessions to recover his postoperative symptoms. But they were never improved. On February 3, 2022, the patient came to the Physical therapy Department of Universitas Udayana Hospital to get physical therapy services for his condition. The patient complained of pain in the distal posterior and medial right thigh and limitations when bending the right knee. In addition, the patient also admitted to having difficulty doing squat movements. There was no problem in the patient's left lower extremity.

Figure 1. Results of postoperative x-ray GCT of the distal femur dextra.

Measurements

Measurements were made on the symptoms expressed by the patient and other physical symptoms that may be experienced. The first measurement of the patient's vital signs showed normal results. On physical examination on static inspection, the area around the patient's right knee appeared swollen and slightly larger than the left knee. A postoperative incision was also seen on the lateral side of the right thigh (after measurement; 16 cm long). In addition, judging from the anatomical position of both the patient's legs tend to be valgus. On dynamic inspection, the patient walks using a crutch for the right leg with a 3-point gait pattern. The patient's right knee was slightly bent during the swing phase, and the patient's right leg was not thoroughly trodden. Palpation was carried out mainly around the swollen right knee and showed no tenderness, but there was tension in the anterior and posterior distal right thigh muscles.

ROM measurements were performed on the right lower extremity in the hip, knee, and ankle regions. ROM measured in the hip region: flexion, extension, abduction, adduction, internal rotation, and external rotation of the hip, for the knee region: flexion and extension, and the ankle region: plantarflexion and dorsiflexion. The movement was carried out actively and passively for each LGS measurement. Immediately after measuring the ROM for each activity, the patient was asked about motion pain. If there is motion pain, measurements are made using a visual analog scale (VAS). The patient feels pain when performing flexion and extension of the right knee, especially in the medial and posterior distal thighs. The results of ROM measurements and motion pain can be seen in **Table 1**. The subsequent measurement was the strength of the right lower extremity muscle using manual muscle testing (MMT). The MMT measurement involved the same movements as in the LGS measurement by adjusting the position of the anti-gravity movement. The results of the MMT measurement are listed in **Table 2**.

Table 1. Pre-intervention right lower extremity ROM measurement results

Movement	Active	Passive	Movement pain
Hip			
Flexion	110° (normal)	110° (normal)	-
Extension	20° (normal)	20° (normal)	-
Abduction	25° (normal)	25° (normal)	-
Adduction	30° (normal)	30° (normal)	-
Internal rotation	30° (normal)	30° (normal)	-
External rotation	40° (normal)	40° (normal)	-
Knee			
Flexion	90° (restricted)	90° (restricted)	+ (VAS = 3)
Extension	10° (restricted)	10° (restricted)	+ (VAS = 3)
Ankle			
Plantarflexion	40° (normal)	40° (normal)	-
Dorsiflexion	30° (normal)	30° (normal)	-

Table 2. Pre-intervention right lower extremity MMT results

Movement	Position	Score
Hip		
Flexion	Supine	5
Extension	Prone	5
Abduction	Supine	5
Adduction	Supine	5
Internal rotation	Sitting at the edge of bed	5
External rotation	Sitting at the edge of bed	5
Knee		
Flexion	Prone	4
Extension	Sitting at the edge of bed	4
Ankle		
Plantarflexion	Sitting at the edge of bed	5
Dorsiflexion	Sitting at the edge of bed	5

Intervention

Physiotherapy intervention, in this case, aimed to reduce pain in the medial and posterior distal right thigh, reduce anterior and posterior distal right thigh muscles, increase right knee flexion and extension, and strengthen thigh muscles (hamstring and quadriceps) so that patients could perform squatting movements and support the load with the right leg and have a normal walking pattern. The intervention was carried out in seven sessions in 3 weeks. The interventions included ultrasound and transcutaneous electrical nerve stimulation (TENS) modalities and several exercise therapies: contract-relax stretching, quadriceps sets, partial squats, one-legged standing exercises, and walking patterns (**Table 3**).

The first modality was ultrasound applied to the hamstring muscles. Giving ultrasound modality aimed to reduce back pain and muscles. The dose of ultrasound was administered to the hamstring muscles with an intensity of 1.0 W/cm^2 and a duration of 5 minutes, as well as to the edges of the adductor and quadriceps muscles with an intensity of 1.0 W/cm^2 and a duration of 3 minutes. Then the TENS modality, which aimed to reduce pain with an intensity of 16.2 W/cm^2, a frequency of 100 Hz, and 10 minutes. The TENS modality used 4 pads with channel electrodes placed on the superior patella (channel 1) and the superior popliteal (channel 2) (**Figure 2**).

Figure 2. Application of TENS and ultrasound modalities

After presenting the modalities, several exercises were performed, including contract-relax stretching, a proprioceptive neuromuscular facilitation (PNF) technique that uses optimal concentric contractions of the quadriceps and hamstring muscles, followed by relaxation and then stretching. Contract relax stretching exercises aimed to lengthen the muscles so that there would be an increase in ROM. This exercise was performed in a prone position lying down. The leg from a neutral position performed a knee flexion movement by applying resistance to the posterior part of the tibia until the patient could reach the ROM. This exercise was hold for a count of 8 and repeated 3 times (**Figure 3**).

The following exercise was the quadriceps set, a muscle contraction exercise without changing muscle length or movement. This isometric exercise involves contracting the muscles with the joints in a static state. This exercise aims to increase the strength of the quadriceps muscle. The patient was in a sitting position with straight legs on the examination bed; the patient was instructed to contract the quadriceps muscle towards the examination bed, hold the contraction for 8 seconds, and can be repeated 3 repetitions (**Figure 4**).

Figure 3. Contract-relax stretching exercise

Figure 4. Quadriceps set exercise

In helping the patient to perform squatting movements, partial squatting exercises were given, which aimed to increase flexion and improve the strength of the thigh muscles, especially the quadriceps. Partial squats were performed with the patient facing the wall and both hands supporting the elbows against the wall. The patient should lower his body as much as possible when approaching the surface or base of support (BOS) when doing a partial squat. Partial squats were performed for 8 seconds with 3 repetitions (**Figure 5**).

Figure 5. Partial squat exercise

In session 6, the patient was no longer using crutches, so a one-leg standing exercise therapy intervention was carried out to train the ability to support using the right leg. One-legged standing exercises activate the leg muscles, especially on the side used for support to form stabilization in the leg. The patient was instructed to stand up, then slowly

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move the left leg towards knee flexion so that the load is on the right leg; the patient stood on one leg for 15 seconds and does 3 repetitions. After the patient's right leg was strong to support, do a walking pattern exercise. The patient was educated and exemplified beforehand about the 2 phases in the walking pattern, namely the stance phase and the swing phase, where for the stance phase, there are heel strike, flat foot, midstance, heel off, and toe-off movements. While in the swing phase, there are pre-swing, initial swing, mid swing, and late swing movements. After being educated and exemplified, the patient was then guided slowly to practice the movement correctly for 4 repetitions (**Figure 6**).

Figure 5. One leg standing exercise

Evaluation

Evaluation of the intervention and comparison of the symptoms experienced by the patient was carried out after each intervention starting from the second session of physical therapy (**Table 4**). In the evaluation of the second and third physiotherapy sessions, from palpation, there were still the patient's anterior and posterior distal right thigh muscles. The patient also complained of pain when doing flexion and right knee with limitations, especially at 70°-90°, so the knee joint ROM was still limited due to the pain. Regarding muscle strength, during a partial squat, the patient could only perform the movement with minimal knee flexion (the buttocks only dropped slightly) and for 5 seconds. As for the walking pattern, the patient has not been able to use his right leg, so he still relied on supporting him with crutches. Based on detailed observations, knee flexion was also very minimal during the swing phase. The patient elevated or rotated the pelvis to swing the right leg forward.

Table 4. Evaluation after interventions

Session	Movement pain (VAS)	Evaluation components: Right knee ROM		Right knee MMT	
		Flexion	Extension	Flexion	Extension
II	3	90°	10°	4	4
III	3	90°	10°	4	4
IV	0	95°	0°	5	5
V	0	95°	0°	5	5
VI	0	98°	0°	5	5
VII	0	100°	0°	5	5

On evaluation in the fourth and fifth physiotherapy sessions, the symptoms experienced by the patient began to show improvement. The right thigh muscles' distal anterior and posterior tension was no longer felt. When flexing and extending the knee with resistance, the pain of motion that appeared earlier also disappeared. LGS knee flexion increased to 95°, and knee extension was capable of a maximum of 0°. The patient could also perform a partial squat with greater knee flexion and lower buttocks than before. The walking pattern also improved along with the decrease in symptoms, where knee flexion began to appear in the swing phase.

During the evaluation session, the patient's right leg could support without crutches. However, some components of the walking pattern still need to be improved. Based on a detailed dynamic inspection, the patient was still slightly rotating the pelvis anteriorly to swing his right leg, the trunk was not upright, and the arms were not swinging maximally because he was still adapting without holding crutches. At the last evaluation session, the patient was increasingly able to walk without crutches but still needed further training to develop the walking pattern better.

Table 3. Intervention

Intervention	Aim	Dose
Ultrasound	Relieves pain and tension in the hamstring muscles and between the adductor and quadriceps muscles.	The intensity was 1.0 W/cm^2 and the duration was 5 minutes for the hamstring muscles, and the intensity was 1 W/cm^2 and the duration was 3 minutes for the adductor border muscles with the quadriceps.
TENS	Reduce pain.	Four pads, intensity 16.2 W/cm^2, frequency 100 Hz, duration 10 minutes. Channel electrodes were placed on the superior patella (channel 1) and superior popliteal (channel 2).
Contract-relax stretching	Lengthening the muscles so that there is an increase in ROM.	8 seconds, 3 repetitions.
Quadriceps set	Strengthens the thigh muscles (hamstrings and quadriceps).	8 seconds, 3 repetitions.
Partial squats	Increase knee flexion and improve maximum strength of the thigh muscles (quadriceps).	8 seconds, 3 repetitions.
One leg standing exercise (started at the fifth session)	Increases the activation of the muscles of the right leg.	15 seconds, 3 repetitions.
Walking pattern (started at the fifth session)	Improve the patient's walking pattern (swing phase).	4 repetitions.

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Discussion

This case report focuses on the intervention given to the symptoms that appeared after GCT removal surgery in a patient. The patient underwent surgical removal of a benign tumor in the distal third of the right lateral femur in November 2021. Based on the incision site, surgical removal of the tumor using a lateral approach. After the tumor was removed, the site of the tumor was filled with bone cement, and internal fixation was applied to strengthen the structure and stabilize the femur and knee. Post-surgery to date, the patient has not been able to overcome the inability of the right leg, especially the distal thigh and knee, to support when squatting and walking. The patient also used a walking aid in the form of crutches. After examination, there was a muscle spasm in the anterior and posterior distal thighs and pain when performing knee flexion and extension movements with resistance. In addition, the patient reported a “locking” feeling when flexing the right knee. These conditions impacted the patient's walking pattern, where from dynamic inspection, the patient did not perform the proper leg swing phase well.

The interventions provided were modalities, manual therapy, and exercise therapy. Ultrasound relaxed the distal medial and posterior thigh muscles in the intervention modality. Ultrasound produced both thermal and mechanical effects. Thermal effects can increase tissue temperature and extensibility, local blood flow, and reduce fluid viscosity in tissues. As for the mechanical effect, ultrasound can accelerate tissue metabolism by stimulating cell permeability and ion transport. All of these effects help in reducing muscle spasm.[9] The ultrasound parameters that can be used are frequencies ranging from 1-3 MHz, with 3 Mhz for superficial tissue and 1 MHz for deeper tissue, continuous mode up to 5 MHz, and intensity. W/cm^2.[9,10]

Another modality used was TENS to reduce pain in the medial and posterior distal thighs. One of the TENS mechanisms is the pain gate mechanism, where the parameters used can activate or excite non-noxious sensory fibers, thereby reducing the transmission of noxious c-fiber stimuli through the spinal cord and higher control center (brain).[11] The mechanism applied to the patient was the frequency of 100 Hz, the intensity of 16.2, and the duration of 10 minutes. Channel electrodes were placed on the superior patella (channel 1) and superior popliteal (channel 2).

The following intervention was manual therapy, namely contract-relax stretching. Contract relax stretching can increase muscle flexibility, joint range of motion, and hamstring and quadriceps muscle strength.[12] Physiologically, there are autogenic inhibition and reciprocal inhibition theories that underlie the contract-relax stretching mechanism. In autogenic inhibition, the target muscle contracts have decreased excitation due to an inhibitory signal from the Golgi tendon organ (GTO) in that muscle. The contraction causes activation of Iβ afferent fibers in the GTO. Afferent fibers send signals to the spinal cord to activate inhibitory interneurons. The inhibitory interneurons then place a stimulus on the motor neurons, which reduces nerve excitation and efferent motor control of the muscle. This reflex spreads the muscle's workload, thereby reducing the motor unit from fatigue, making the contracted muscle relax. In reciprocal inhibition, the antagonist muscle contracts voluntarily, and the stretched target muscle relaxes. Relaxation of the target muscle is caused by a decrease in innervation activity and an increase in the inhibition of the proprioceptive structures of that muscle. At the spinal cord level, signaling Iα afferent fibers enter the spinal cord and exit on collateral branches that interact with interneurons, then send signals to motor neurons in the GTO of the relaxation target muscle. This interaction causes inhibition and relaxation of the target muscle so that it can stretch.[13]

In addition to contract-relax stretching, quadriceps set exercise therapy was also performed. In the quadriceps set, there is an isometric contraction mechanism without movement. The origin and insertion of the muscle are immobile, and there is no change in muscle length. Actin and myosin myofilaments form cross-bridges and exert internal forces, but external forces can compensate.[14]

Partial squats promote isometric contractions primarily of the muscles of the lower extremities. The gluteus maximus and quadriceps (rectus femoris, vastus lateralis, vastus medialis, and vastus intermedius) act as agonist muscles for the squat movement. While the hamstrings (biceps femoris, semitendinosus, and semimembranosus), erector spinae, adductor magnus, and gastrocnemius contract synergistically, and the transversus abdominis, multifidus, internal oblique, pelvic floor, rectus abdominis, and external obliques function as stabilizers between agonist and antagonist muscle contractions.[15]

Furthermore, one leg standing exercise was performed when the patient could walk without crutches. This exercise trains the adaptation of the primary muscles, namely the quadriceps muscles, isometrically, while the contracting secondary muscle groups include the gluteus, adductor, hamstring, iliopsoas, and iliotibial band. When the patient stands on one leg, an action potential occurs in the motor neuron that triggers the release of calcium ions from the sarcoplasmic reticulum. Calcium ions bind to troponin on actin which causes tropomyosin to move closer to actin. The actin and myosin filaments form a cross-bridge. The hydrolysis of ATP then causes the myosin to rotate, detaching from the cross-bridge and binding to other actin so that sliding occurs. The sliding mechanism causes the shortening of the sarcomere, which causes muscle contraction.[16] In addition, the patient performed exercises in the correct gait pattern. Patients are educated and trained about two phases in the walking pattern, namely the stance phase and the swing phase, where for the stance phase, there are heel strike, flat foot, midstance, heel off, and toe-off movements. While in the swing phase, there are pre-swing, initial swing, mid swing, and late swing movements.[17]

Conclusion

This case report shows that physiotherapy interventions in the form of modalities, manual therapy, and postoperative exercise therapy for giant cell tumor of the distal femur dextra can gradually reduce pain, relax the tension of the anterior and posterior distal thigh muscles, increase muscle flexibility, joint range of motion, and increase muscles strength (hamstrings and quadriceps). The walking pattern has improved but still requires further practice to show progress. The limitations of this case report are the lack of time and opportunity to observe the patient's condition further. Hopefully, this case report can be used as a reference for the treatment of postoperative physiotherapy for giant cell tumor distal to the right femur.

Conflict of interest

The author declares no conflict of interest in making this case report.

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Author's contribution

IPGSA designed a case report design, AJ performed physiotherapy interventions on patients, NKAY, NMRP, NMIS observed physiotherapy interventions conducted and compiled case reports, NLVR and MI collected literature and compiled case reports, and TDP reviewed and edited case reports.

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