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Case report
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Giant Cell Tumor of the Metacarpal and Its Intervention to Preserve Joint Function: A Case Report

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ABSTRACT

Background: Giant cell tumor (GCT) is one of the most common benign bone tumors, but it has a high recurrence rate and is aggressive. It can occur elsewhere, but frequently in the distal femur and proximal tibia. The goal of treatment is to remove the tumor cells and maintain the metacarpophalangeal function. Various modalities exist to remove the tumor cells from curettage, wide excision, radical excision, or amputation. Reconstruction following the removal of tumor cells also varied by using graft, bone cement, prosthesis, or arthrodesis. There are no definitive guidelines to determine which modalities are the best, especially in unusual sites. In this case report, we present an unusual site of GCT in the second metacarpal, and clinical outcomes after the 1-year final follow-up were nearly normal.

Case Presentation: A 22-year-old female presented to the hospital with a history of a lump and intermittent pain in the right hand for 2 years. Physical examination and radiograph suspected an unusual site of GCT and no cartilage involvement. A core biopsy was taken, and a GCT was confirmed. Wide excision, preserving the native joint of the metacarpal, and reconstruction using autologous non-vascularized fibular graft with the help of K-wire and adjuvant of hydrogen peroxide.

Results: Constant improvement of clinical outcomes post-operatively with Michigan Hand Outcomes Questionnaire (MHQ) score was nearly normal, and there was no sign of recurrence at 6-month follow-up.

Conclusion: Our report suggests that wide excision and reconstruction by fibular struts with a preserved native metacarpal joint, followed by hydrogen peroxide as an adjuvant and K-wire as a fixator, could be used as a combination therapy with good results.

Keywords: giant cell tumor, metacarpal, combined therapy, autografting

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BACKGROUND

Giant cell tumor (GCT) is one of the most common benign bone tumors. It usually occurs in around 55% of cases in the long bones, such as the distal femur and proximal tibia. The hand is the rarest site of GCT, around 2% of all hand tumors (Memon and Patankar, 2018). GCT most

commonly affects young adults, with a median age of onset ranging between 20 and 50, with less than 3% occurring before age 20 and 13% occurring after age 50 (Altayeb *et al.*, 2021). Prevalence of GCT is slightly more common in females than males, whereas it is also more common in Asian populations than in Western populations (Verschoor *et al.*, 2018).

Initially, GCT was first described by Cooper and Travers in 1818. The characteristic of GCT is that it is locally aggressive, usually in the metaphyseal region extending to the epiphysis, and has a high recurrence rate (Cao *et al.*, 2017) (Gunasegaran, Irawan and Yantisetiasti, 2016). Although it rarely occurs, lung metastasis could exist in GCT, which the World Health Organization (WHO) 2020 classified it as an intermediate tumor (James and Davies, 2005)(Klenke et al., 2011). Recent molecular findings suggest that the etiology of GCT was a true neoplastic origin rather than a reactive or inflammatory process. It is the stromal cell responsible for the neoplastic element of the tumor. There are 2 cell lines in the stromal cells, in which mononuclear spindle-shaped cells are considered as the neoplastic characteristics (Kremen et al., 2012). It is hypothesized that a mutation in the histone H3F3A gene and alteration of the p53/MDM2 pathway as the drivers for the neoplastic. It is believed that stromal cells secreted Receptor Activator of Nuclear Factor kB Ligand (RANKL), Macrophage Colony Stimulating Factor (M-CSF), and Stromal Derived Cell Factor 1 (SDF1) which then increased Receptor Activator of Nuclear Factor kB (RANK) in monocytes, attract monocytes from the vascular which eventually formed giant cells characteristic (Kim et al., 2012)(Features, 2014).

Diagnosis of GCT is usually found in an advanced stage. Most GCTs in the hand extend to the epiphysis and diaphysis with a central location and involve articular cartilage. It was postulated that it occurred because of limited free space in the hand (Lucas et al., 2015). The clinical examination, often found at first presentation, included swelling, limited function, and radiological examination, as the size of the tumor was >50% of the bone diameter, cortical thinning, no sclerosis, and significant soft tissue involvement. Core needle or open biopsy is usually enough as the standard initial diagnostic procedure (Lenze et al., 2017).

The main purpose of the management of bone GCT is to eliminate the tumor cells, prevent recurrence, and preserve function. There are various modalities that exist which can be divided into local and systemic treatment. Local treatment included interventions such as intralesional curettage, wide excision, and en bloc resection. In addition, as the intervention is applied, there are adjuvants that can be used. Several adjuvants exist, such as polymethyl methacrylate (PMMA), liquid nitrogen, phenol, sterile water, and hydrogen peroxide 3%. There were no definitive guidelines on which adjuvant gave the best result (Mozaffarian, Modjallal and Vosoughi, 2018).

Systemic treatment, which has been used on bone GCT, such as bisphosphonates and denosumab. Its used first explored in the early 2000s and was inspired by the success in treating osteoporosis, bone metastases, and osteolytic lesions. The role of systemic treatment in GCT is different from local treatment, which is to reduce tumor progression, not eliminate the tumor cells. Therefore, they are also called neoadjuvants and cannot be used alone or were preserved for unresectable cases. There is still ongoing research about the use of these (Omlor et al., 2019).

Various treatments exist, but there is no evidence which combined therapy gives better results (Patel and Nayak, 2015). There are only recommendations for treatment at the usual site of location based on aggressiveness (Zou et al., 2019). It relied on Campanacci's staging for classifying the aggressiveness. There is no recommendation for a rare site such as the metacarpal. On the recommendation of bone GCT, for the usual site in Campanacci stage 1, 2, or stage 3 with limited soft tissue invasion, curettage is suggested as much as possible to achieve better postoperative function then followed by adjuvants. A higher recurrence rate was reported in curettage patients compared with excision, especially wide excision (Varga and Lazary, 2024)(War et al., 2020). Because of that, we present a case report of GCT in the second metacarpal (MC II) treated by wide excision with preservation of native joints, then reconstruction with fibular strut, followed by adjuvant. Here, we also use wire fixation to minimize the cost. We also compare the clinical outcomes by MHQ scores, pre- and post-operative, and look for signs of recurrence during follow-up.

CASE PRESENTATION

A 22-year-old female presented to our hospital with symptoms of a lump in her right hand that kept increasing in size for two years. Symptoms were also accompanied by pain and limited second metacarpo-phalangeal (MCP II) flexion. The patient described moderate limitations in performing daily activities. There is no history of recent or previous trauma. Previous history of fever and a decrease in body weight were denied.

The patient had been having the symptoms for 2 years. Initially, the patient refused to seek medical attention because there was only a lump. Six months later, the patient started to feel pain with slightly limited daily activities, specifically in her right hand. Then, the patient sought traditional care until before presented to our hospital. There was no history of neoplasm or metabolic disturbances. There was no history of familial neoplasm or syndrome.

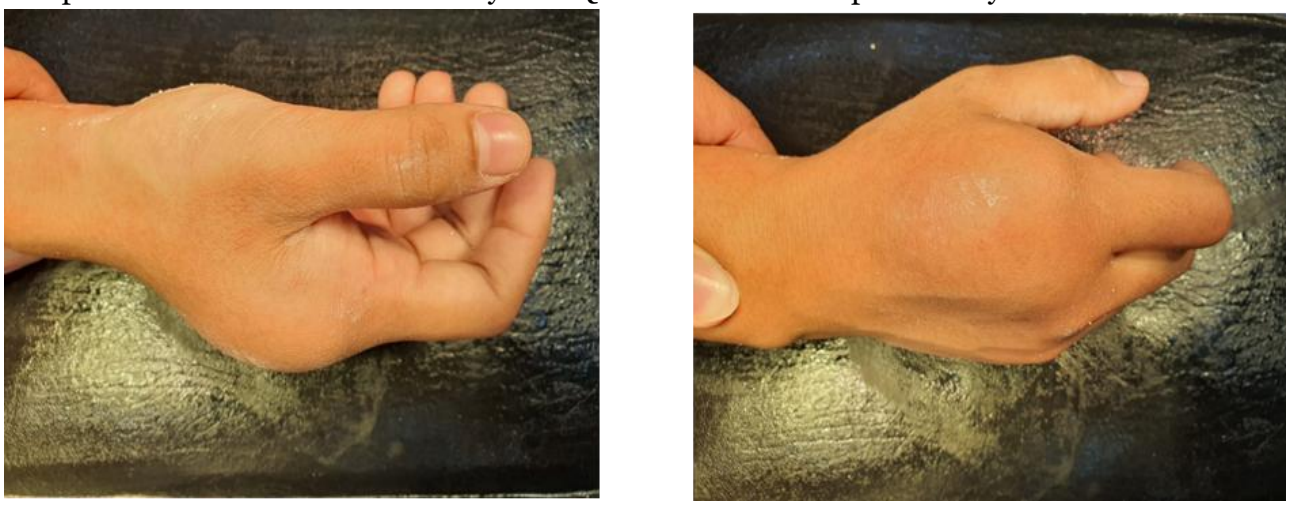

Figure. 1 Clinical photo pre-operative.

Physical examination revealed a female with good general health. There was no sign of systemic manifestation such as anemia, fever, or regional lymphadenopathy. On the dorsal surface of the right MC II, there was a 4x4 cm lump, regular, hard, tender, not

mobile, and not attached to the skin (Figure. 1). There were no scars or venectation and no signs of inflammation such as kalor or dolor. Range of motion diminished with right MCP II flexion (0-70), and the Michigan hand outcome questionnaire (MHQ) was decreased. There were no signs of neurological compromise, with sensory and motoric function normal.

AP/lateral radiographs of the right manus showed a lucent lytic lesion and expansile remodeling from the metaphysis extending to the distal shaft of the MC II, indicating a progressive nature. There was cortical thinning, but the cortex was still intact with no periosteal reaction and involvement of the articular cartilage of right MCP II. There was no appearance of soft tissue involvement (Figure 2).

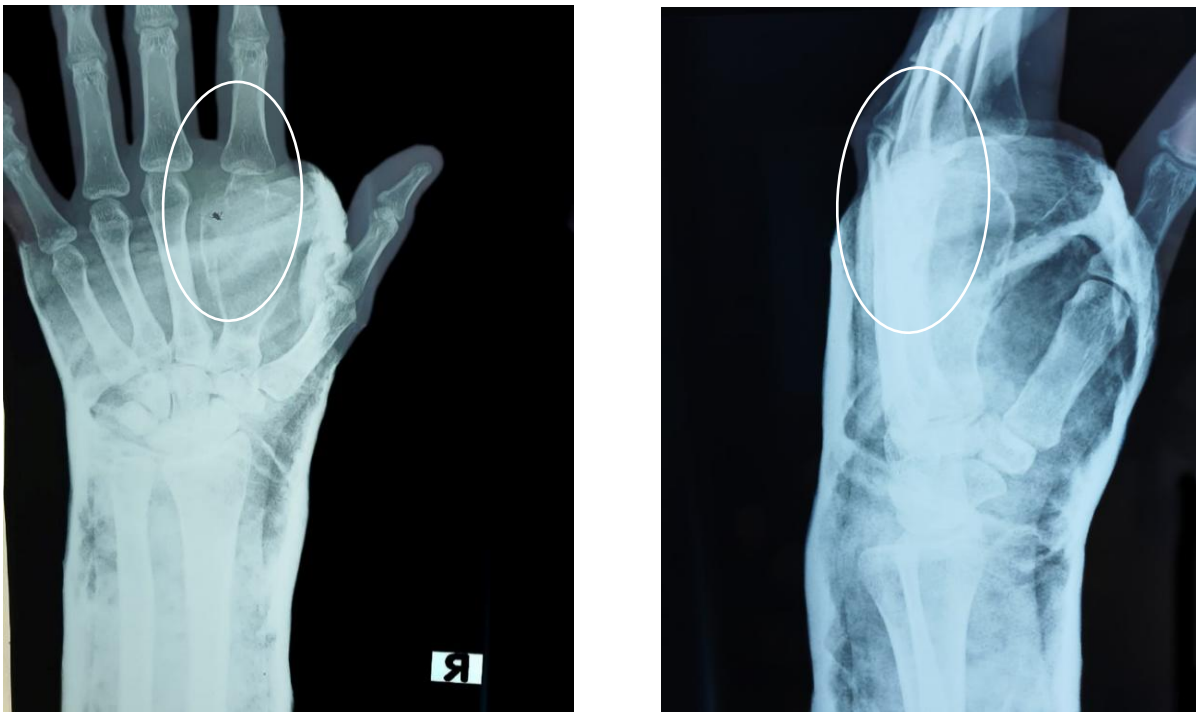

Figure. 2 X-ray pre-operative.

From the X-ray findings, we classified it as Campanacci stage 2. Then, the patient was diagnosed with a GCT. The case timeline was outlined in Table 1.

Table. 1 Case timeline of giant cell tumor of the metacarpal

Date	Event
2022 to June, 2024	The initial lump keeps increasing in size Slight limitation of daily activities Sought traditional care and were given an analgesic
June 3, 2024 (Pre-operative)	The patient presented to our hospital with a lump. Moderate limitation of daily activities. Physical examination revealed a lump 4x4 cm, regular, hard, tender, not mobile, and not attached to the skin. Range of motion diminished with right MCP II flexion (0-70), and the Michigan hand outcome questionnaire (MHQ) pre-operative was done. Plain AP/L right manus radiograph showed a lucent lytic lesion with

Date	Event
	Campanacci stage 2. GCT was diagnosed. Wide excision with preservation of articular cartilage, plus adjuvant and fibular strut reconstruction with the help of K-wire, was planned.
June 10, 2024	The patient underwent the management A post-operative radiograph was done
August 26, 2024	Union graft was found, and the K-wire was removed
September 2, 2024 (3-month post-operative)	The right MCP II flexion (0-80) MHQ 3-month post-operative was done There was no sign of recurrence
December 12, 2024 (6-month post-operative)	The right MCP II flexion (0-90) MHQ 6-month post-operative was done There was no sign of recurrence

RESULTS

A dorsal MC approach in the middle of the MC II shaft was performed. The extensor muscles and underlying structure were retracted to expose the MC II. Identified the characteristic of the tumor, the tumor margin, and the healthy bone. Macroscopically, it was a fleshy, red-brown mass, and partially destroyed cortex (Figure 3). Next, a wide excision of the right MC II was performed with a free tumor margin of 1 cm. The head and base of MC II were preserved.

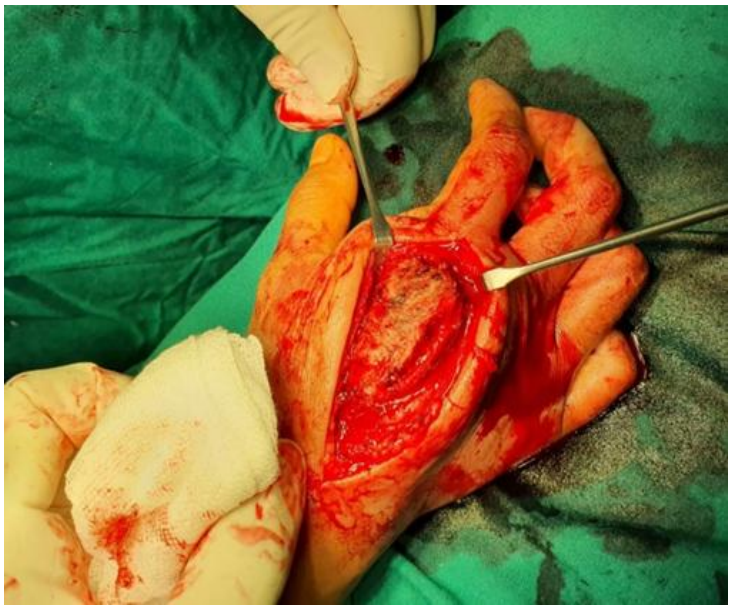

Figure. 3 Intraoperative macroscopic appearance of the tumor.

A non-vascularized fibular graft was used by a minimally invasive technique. It was performed on the ipsilateral limb. A 4.5 cm fibular strut length was planned for the harvested. Two incisions were performed, 1 cm each, with 6.5 cm apart in the mid-diaphysis of the fibula. Incision was performed until the fascia. After opening of fascia, identified the space of the soleus and peroneal muscles. Then explores the space until it reaches the periosteum and incises. Next, cautiously detached the subperiosteal. The fibula was found and then excised. After the proximal and distal

ends of the fibula were excised, a clamp was used to grasp the graft. An adjuvant of hydrogen peroxide 3% was used to prepare the graft bed. Finally, the fibula graft was placed and positioned with the proximal and distal ends of the graft met the medullary cavity. Then, external fixation using a K-wire was drilled through the head, graft, base, and carpal (Figure 4).

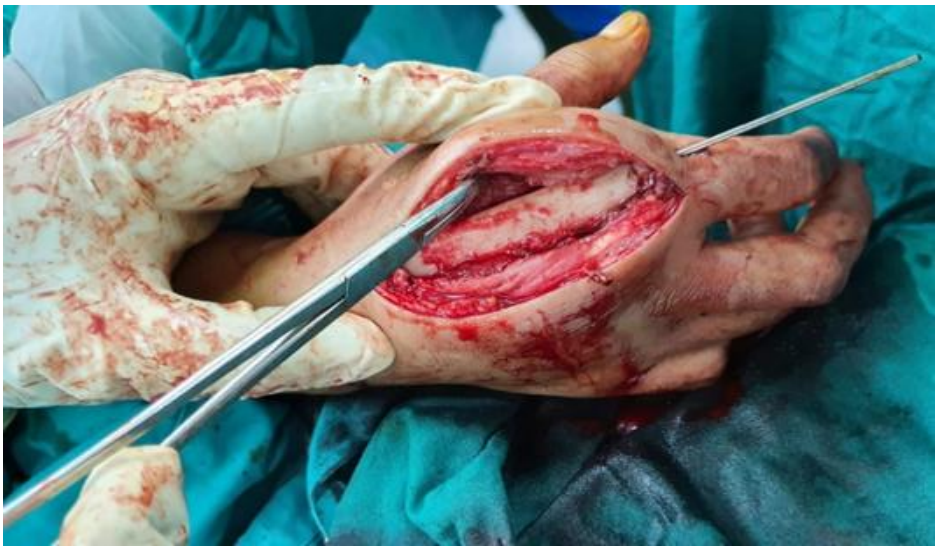

Figure. 4 Intraoperative post external fixation of graft.

The diagnosis was confirmed as a GCT by biopsy (Figure 5), and post-operative radiographs showed that the alignment of the graft with the remaining bone was good (Figure 6).

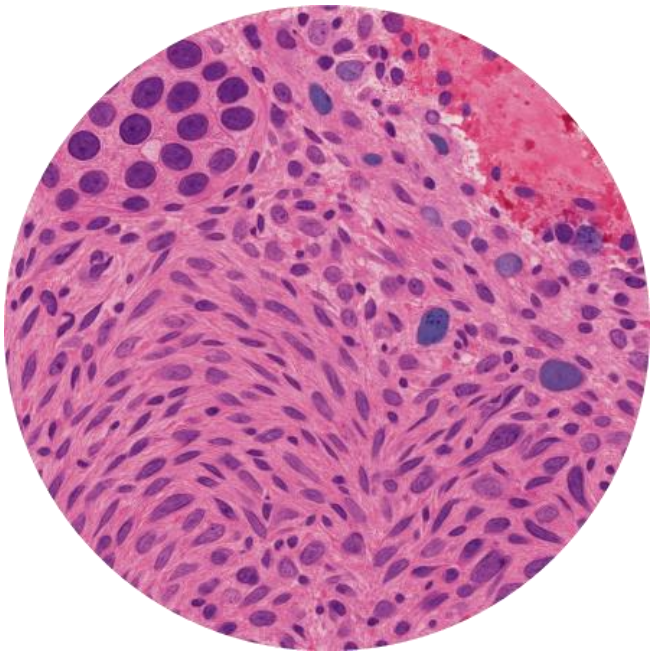

Figure. 5 Histopathological appearance of biopsy.

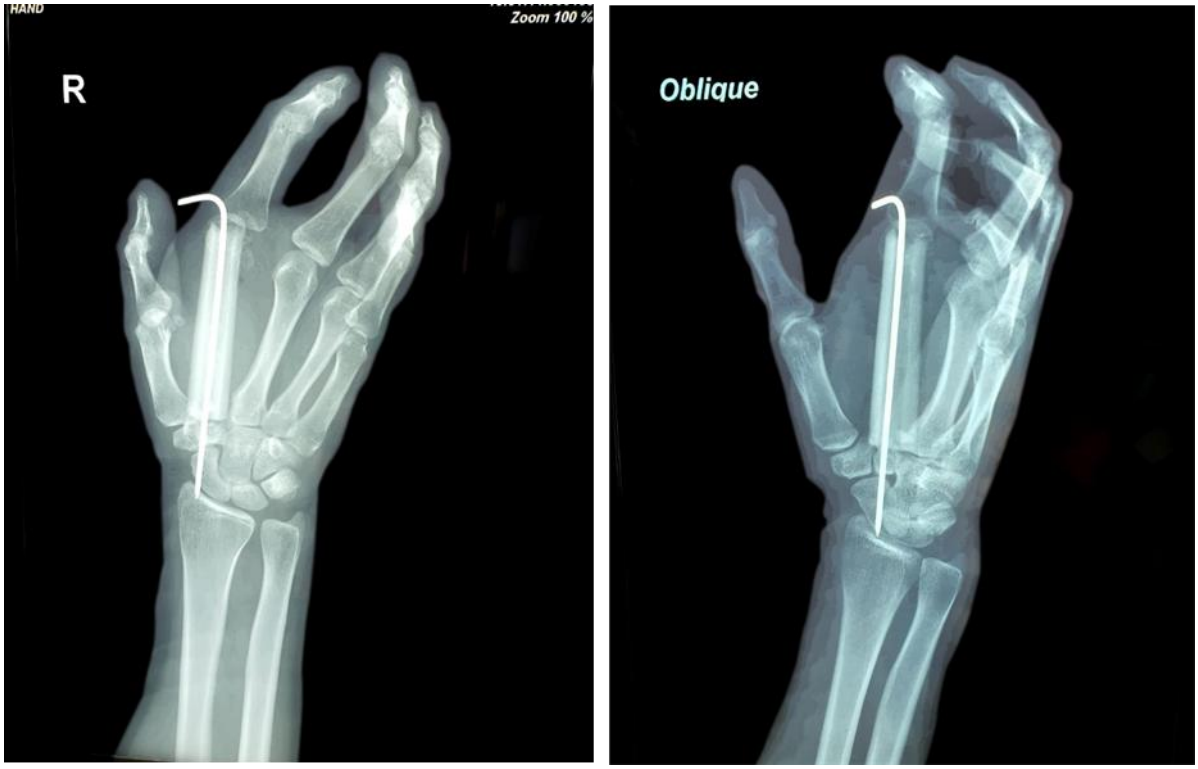

Figure. 6 X-ray post operative.

At a one-week follow-up, there were no signs of infection on the incision site. Weight-bearing and active movement of MCP II were prohibited until the union of the graft with the remaining structure. At one-month follow-up, active movement was suggested, but weight bearing was still prohibited. At two months post-op, the graft union with the remaining structure was found, and the K-wire was removed. Active movement and weight bearing were recommended to the patient. Six-month post-op, MCP II flexion was nearly normal (0-90), and the MHQ was improved (Table 2). The patient was followed until 6 months post-op, and there was no sign of recurrence, such as a new onset of pain or lump in the operation site.

DISCUSSION

Giant cell tumor is a benign, aggressive neoplasm that usually occurs in adults aged 20-40 years. Its prevalence is around 5% of all primary bone tumors and approximately 20% of all benign bone tumors. Most of the GCTs are found in the epiphysis of the distal femur, proximal tibia, and distal radius. Its incidence in the hand, especially the metacarpal, is only <2% (Zheng *et al.*, 2021). Although the rarity of GCT in the metacarpal, it is often more aggressive and has a high recurrence rate. It is postulated because of the small surface area and the proximity to the adjacent joint (Deventer et al., 2022)(Vari et al., 2022).

The etiology of GCT is not well understood, but a dysfunction of stromal cells plays the main role. There are also several studies that found a mutation of the H3F3A gene in stromal cells. Because of that, GCT is believed to be caused by truly neoplastic clonal cells. There is no evidences that find the relation of GCTs with trauma, infection, or other syndromes

(Futriani et al., 2022)(Han et al., 2022). Stromal cells will produce chemokines such as MCP-1 and SDF-1 that will attract monocytes that express CXCR-4 and RANK. RANK will attach to stromal cells that express RANKL, which will urge mature osteoclast differentiation and secrete M-CSF. In addition, stromal cells will also produce cytokines that are responsible for osteoclastogenesis, such as interleukin (IL)-6, IL-11, IL-17, and parathyroid hormone-related protein (PTHrP). These monocytes ultimately will fuse and form a multinucleated giant cell like an osteoclast. As of that, histological analysis of GCT will identify spindle-shaped stromal cells, circular-shaped monocytes, and multinucleated giant cells like osteoclasts. Although GCT is benign, it expresses potential metastasis. It usually happens upon recurrence in 3% of cases, with pulmonary tissue and breast tissue being the predominant sites (Tschavoll et al., 2023).

Clinical evaluation of GCT, the patient usually complains of local pain, a lump, and limited range of movement. Imaging from conventional radiograph will find a lytic lesion with little to no margin, without sclerosis, and thinning or perforation of the cortex. Imaging can help differentiate aggressiveness based on Campanacci staging. Campanacci stage I has a well-defined margin, intact cortex, and is surrounded by capsule; next, Campanacci stage II has a relatively well-defined margin, thinning of cortex, and is moderately expanded; latter, Campanacci stage III has indistinct borders and perforation of cortex with soft tissue involvement (Ferdause et al., 2023). Magnetic resonance imaging (MRI) is indicated for the suspicion of soft tissue extension. Histological analysis of GCT will find multinucleated giant cells extending evenly with mononuclear stroma cells (Futriani et al., 2022).

Treatment of GCT is determined based on location and aggressiveness. Because of the rare location, there is no specific recommendation for GCT in the hand, especially the metacarpal. The recommendations that exist are limited to weight-bearing extremities or long bones such as the femur or the humerus (Jha and Chaudhary, 2023). For Campanacci stage I and II, curettage is recommended to preserve the joints and achieve nearly normal function. The use of adjuvants is also recommended to prevent recurrence, but there is no specific adjuvant that should be used. For large extraosseous lesions with Campanacci stage III, en-bloc resection (EBR) is indicated. Bone GCT often occurs in the epiphysis or metaphysis, which, after intervention such as wide excision or EBR, will require reconstruction (Ali et al., 2024). A few reports have documented a GCT in MC, but usually, their approach was different, either by intralesional curettage, partial excision, or wide excision with reconstruction using a prosthesis or plate as a fixator (Pradana and Edward, 2021; Ahmed, Moore and Stacy, 2015).

In this case report, we present a rare case of GCT in the MC II treated with a wide excision approach, preserving the native joint and replacing it with a non-vascularized fibular graft and adjuvant therapy using 3% hydrogen peroxide. We then used a K-wire as a fixator. The goal of treatment is to preserve function and prevent recurrence. Larger size, location in cortical bone, and aggressiveness are characteristics suitable for wide excision (Memon and Patankar, 2018; Varga and Lazary, 2024; Saleh *et al.*, 2023).

Here, we use wide excision in regards to the GCT location in the metacarpal, which has a more aggressive characteristic

as we mentioned above. A study by Isheth et al. found that wide excision prevents recurrence significantly more than intralesional curettage plus adjuvant therapy (Omlor et al., 2019; May et al., 2007). Makoto et al. found that wide excision was commonly used and reliable in bone tumors rather than marginal or radical. An adjuvant therapy of 3% hydrogen peroxide was used in this case to decrease the likelihood of recurrence. A study by Omlor et al. found that additional cleaning of the tumor cavity with hydrogen peroxide significantly reduces the recurrence rate (Tsukamoto et al., 2024; Mavrogenis et al., 2017). Meanwhile, wide excision had several drawbacks, such as decreased function and surgical complications (Jalan et al., 2022). According to Divesh et al., a decrease in functional outcomes was associated with increased VAS scores and decreased ROM. So, to decrease the potential drawback, we suggested preserving the joint, as in our case report, and we decided on a wide excision approach to preserve MCP II (Taran et al., 2023).

Here, we used an ipsilateral fibular graft using a minimally invasive technique similar to the previous study from Shentil et al (Muzzammil et al., 2024). Many graft choices are available, and one of the most common is fibular and iliac grafts, especially in bone tumors. We hypothesized fibular graft was more suitable than the iliac. There are several reasons, such as the fact that a fibular graft is a cortical graft with more structural support, more compatible with the shape of the metacarpal, and a remodeling rate rather than an iliac bone graft (Igrec et al., 2025). In line with Muhammad et al., the hypertrophy and healing rates were superior to those of an iliac graft. There were also no significant differences regarding post-operative complications (Abdel-hamid, Abulsoud and Bissar, 2020; Muzzammil *et al.*, 2024). Finally, a K-wire was used as a fixator. Some considerations include the size of the remaining MC head and base, to prevent more soft tissue injury, which is cheaper, and prevents a secondary operation. One study concluded that K-wire was as effective as a mini plate in MC (Wang, Sun and Jiang, 2019).

Outcomes were measured pre-operative, at 3 months, and 6 months post-operatively by ROM of MCP II flexion, MHQ, and signs of recurrence. ROM and MHQ were slightly improved 3 months post-operative and significantly improved to near normal 6 months post-operative. There were no signs of recurrence, such as a new onset of lump or pain, after 12 months post-operatively. Nevertheless, there were some limitations in our study, which included a shorter duration of follow-up compared to the other studies that usually look for signs of recurrence.

In summary, GCT, especially in the hand, is a rare lesion. In addition, because of minimal symptoms in early disease and its aggressiveness, it is usually diagnosed at an advanced stage, where higher prevalence of cartilage involvement and a recurrence rate. There are no guidelines on which combined therapy will result in the best clinical outcome and prevent recurrence. Wide excision and replacement by fibular strut with preserved native joint in MC and use of 3% hydrogen peroxide as an adjuvant could be considered a treatment of GCT. K-wire as a fixator could be used, and the overall result is nearly normal clinical outcomes with no signs of recurrence.

AUTHORS' CONTRIBUTIONS

YEK was the main treating surgeon who presented the idea. ETP and CC collected, wrote the manuscript, and reviewed the

paper, besides making corrections with the support of YEK. All authors have critically reviewed and approved the final draft and are responsible for the manuscript's content and similarity index.

ETHICAL APPROVAL

None.

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None.

CONFLICTS OF INTEREST

There are no conflicts of interest.

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