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# Spinopelvic Reconstruction for a Giant Cell Tumor Involving the Sacroiliac Joint: A Case Report

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## Abstract

*Background/Aim*: Giant cell tumors of the bone (GCTB) involving the sacroiliac joint are uncommon and pose significant surgical challenges due to their proximity to major neurovascular structures and the complexity of stabilizing the pelvic. We describe a case of sacroiliac joint GCTB successfully managed with preoperative denosumab, piecemeal tumor resection, and spinopelvic reconstruction.

*Case Report*: A 34-year-old woman presented with progressive gluteal pain and swelling. Imaging demonstrated an osteolytic lesion extending from the left sacrum to the ilium with extraosseous soft-tissue involvement. Histopathology confirmed the GCTB diagnosis. To facilitate resection and reduce intraoperative blood loss, denosumab (120 mg monthly) was administered for five months, resulting in marked peripheral ossification on computed tomography. The tumor was resected *via* a posterior approach with preservation of the S1–S3 nerve roots. Spinopelvic reconstruction was achieved using L4-S2 fixation, S2 alar-iliac screws, artificial bone graft, and unsintered hydroxyapatite/poly-L-lactide mesh. The postoperative course was uneventful, and no neurological deficits were observed. Follow-up computed tomography at three months and one year demonstrated stable instrumentation, preserved graft integrity, and no evidence of local recurrence.

*Conclusion*: Preoperative denosumab followed by posterior tumor resection and spinopelvic reconstruction provided excellent short-term tumor control and functional recovery in this patient with sacroiliac joint GCTB. Given the high recurrence risk associated with pelvic lesions, continued long-term surveillance is essential.

**Keywords:** Spinopelvic reconstruction, giant cell tumor.

## Introduction

Giant cell tumor of the bone (GCTB) is a benign but locally aggressive primary bone tumor characterized histologically by mononuclear stromal cells intermixed with multinucleated giant cells (1, 2). It accounts for approximately 5% of all primary bone tumors and typically affects young adults in their third to fourth decades of life, with a slight female predominance (2, 3). GCTB most commonly arises in the epiphyseal–metaphyseal regions of long bones, particularly around the knee, involving the distal femur and proximal tibia (1, 2).

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Although the majority of GCTBs occur in long bones, involvement of the sacrum or pelvis is relatively uncommon, representing approximately 2-8% and 1.5-6% of cases, respectively (4, 5). Pelvic GCTBs are often diagnosed at a later stage because of their deep anatomical location and nonspecific early symptoms. Consequently, they tend to reach substantial size before detection. Their proximity to major neurovascular structures further complicates management, making en bloc resection challenging and frequently necessitating complex reconstruction. Moreover, pelvic lesions are associated with a higher risk of local recurrence than those in the appendicular skeleton (5, 6).

The pathogenesis of GCTB is driven by dysregulated expression of receptor activator of nuclear factor kappa-B ligand (RANKL) by neoplastic stromal cells, which promotes recruitment and activation of osteoclast-like giant cells (7, 8). This molecular insight led to the development of denosumab, a fully human monoclonal antibody targeting RANKL, which is an important therapeutic option for patients with unresectable tumors, in surgical downstaging, and for recurrence prevention since its approval in 2013 (9, 10). Accumulating evidence supports denosumab's efficacy in inducing tumor ossification, reducing vascularity, and facilitating safer surgical resection (9-12).

Here, we report a case of GCTB arising in a patient's sacroiliac joint that was managed with preoperative denosumab followed by tumor resection and spinopelvic reconstruction. A review of the relevant literature is also provided.

This study was conducted in accordance with the Declaration of Helsinki. This case report is also based on existing clinical records, and thus ethical approval from an institutional review board was not required. Written informed consent for participation and publication was obtained from the patient.

## Case Report

A 34-year-old woman presented with progressive gluteal pain and swelling. She had no significant past medical history, and a neurological examination revealed no abnormalities.

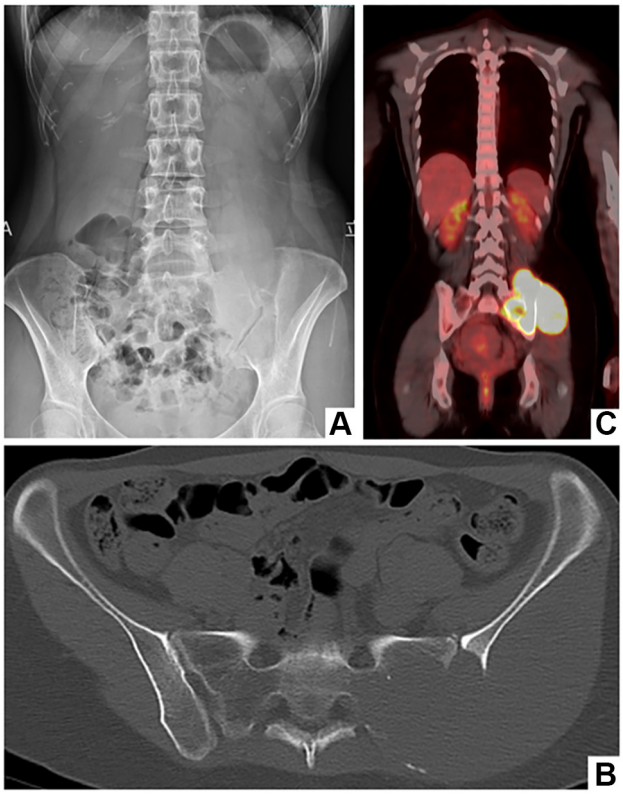



Figure 1. *Preoperative imaging findings. A) Radiograph showing a lucent lesion involving the left sacrum and ilium. B) Computed tomography demonstrating an osteolytic lesion with an associated extraosseous soft-tissue mass. C) Fludeoxyglucose–positron emission tomography/computed tomography showing intense uptake at the left sacrum and ilium, with a maximum standardized uptake value of 13.3.*

Plain radiographs of the lumbar spine demonstrated a lucent lesion involving the left sacrum and ilium (Figure 1A). Computed tomography (CT) confirmed an osteolytic lesion with an associated extraosseous soft-tissue mass (Figure 1B). Fludeoxyglucose–positron emission tomography/CT showed intense uptake with a maximum standardized uptake value of 13.3 (Figure 1C). Magnetic resonance imaging revealed an iso-intense lesion on both T1- and T2-weighted sequences, with a high-signal intraosseous and extraosseous mass centered on the left sacroiliac joint (Figure 2A-C). Gadolinium-enhanced T1-weighted images demonstrated heterogeneous enhancement throughout the tumor (Figure 2D and E).

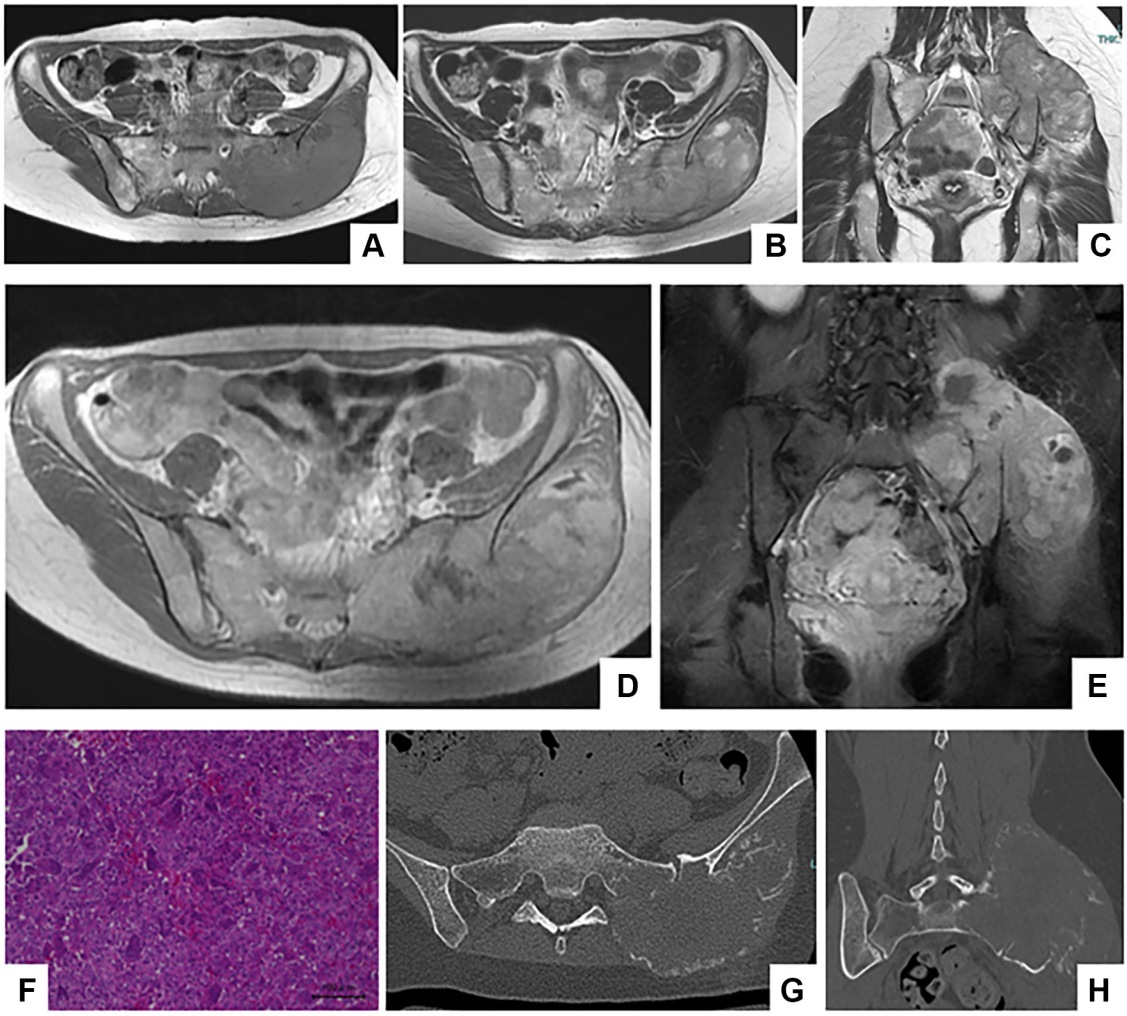



Figure 2. *Histopathological and preoperative magnetic resonance imaging findings. A-C) Magnetic resonance imaging showing an isointense lesion on T1- and T2-weighted images, with a high-signal intraosseous and an extraosseous mass centered on the left sacroiliac joint. D, E) Gadolinium-enhanced T1-weighted images demonstrating heterogeneous enhancement throughout the tumor. F) Hematoxylin–eosin-stained tumor section (200×) showing numerous multinucleated giant cells. Scale bar=100 μm. G, H) Computed tomography after five cycles of denosumab treatment showing peripheral osteosclerosis around the tumor.*

Given the patient's age and imaging characteristics, Ewing sarcoma was initially suspected, and an incisional biopsy was performed. However, histopathology revealed no signs of malignancy. However, multinucleated giant cells were noted, confirming a diagnosis of GCTB (Figure 2F).

*Treatment.* A total tumor excision with reconstruction was planned because complete surgical resection was deemed feasible. To reduce intraoperative bleeding and promote peripheral ossification, denosumab (120 mg monthly) was administered for five cycles. Follow-up CT demonstrated marked peripheral sclerosis, indicating a favorable therapeutic response (Figure 2G and H).

*Surgery*. The surgery was performed under general anesthesia with the patient in the prone position. A posterior approach was selected, and an approximately 30-cm S-shaped incision was made from the L4 level to

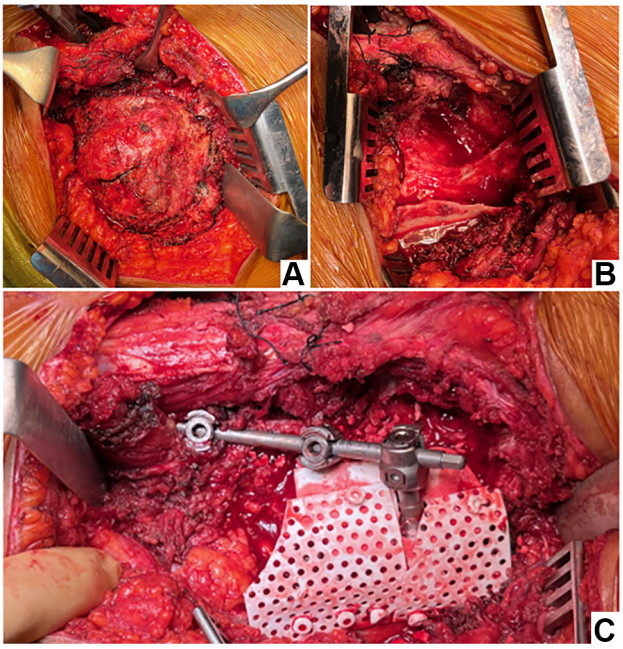



Figure 3. *Intraoperative findings. A) Posterior exposure revealing the ossified surface of the tumor after the skin incision. B) Photograph showing the nerve roots. After posterior tumor resection, the left S1, S2, and S3 nerve roots were identified at the sacrum–tumor interface. C) Photograph demonstrating filling of the bone defect. After tumor removal, artificial bone was packed into the defect and covered with Superfixorb. Posterior fixation from L4 to S2 was performed.*

the left ilium directly over the tumor. The tumor surface exhibited marked ossification, whereas the internal components remained soft (Figure 3A). Tumor removal was carried out in a piecemeal fashion.

The left S1, S2, and S3 nerve roots were identified at the interface between the sacrum and the tumor. Resection was performed along this boundary, preserving all nerve roots while excising the suspected tumor tissue (Figure 3B). Following tumor removal, the resection cavity was treated sequentially with 99% ethanol and liquid nitrogen and subsequently irrigated with distilled water.

L4-S2 posterior fixation was performed for reconstruction. Left S1 and S2 alar–iliac screws were inserted to achieve maximal fixation within the remaining sacrum and ilium. The bone defect was filled with artificial bone graft, and a bioresorbable unsintered hydroxyapatite/poly-L-lactide mesh (Super Fixsorb®, Teijin Medical Technologies, Osaka, Japan) was contoured and secured to the ilium to reinforce the reconstruction (Figure 3C).

Postoperative radiographs and CT scans demonstrated stable implant positioning with no evidence of displacement. No residual calcified tissue suggestive of remaining tumor was observed, and the artificial bone graft was appropriately situated within the defect (Figure 4A-E).

*Postoperative course.* The patient was instructed to remain completely non-weight-bearing for three weeks, after which gradual weight-bearing activities were permitted according to their pain tolerance. Heavy labor and strenuous exercise were restricted for two months. No neurological deficits were observed throughout the postoperative period. The patient was discharged one month after surgery and subsequently returned to normal daily activities without difficulty. Because the tumor was considered completely resected, postoperative denosumab therapy was not administered.

CT imaging at one year postoperatively showed no abnormalities in the instrumentation or graft position and revealed no evidence of local recurrence (Figure 4F and G).

## Discussion

This case highlights the effectiveness of combining preoperative denosumab, piecemeal tumor resection, and spinopelvic reconstruction for the management of sacroiliac joint GCTB. Lesions in this region pose unique challenges due to their deep anatomical location, proximity to neurovascular structures, and the difficulty of achieving wide surgical margins. The present case provides several important insights into the optimal use of denosumab, surgical strategy, and postoperative surveillance for sacroiliac joint GCTB.

*Role and duration of preoperative denosumab.* Since its approval in 2013, denosumab has become an important adjunct treatment in the management of GCTB (9, 10). Preoperative administration promotes peripheral

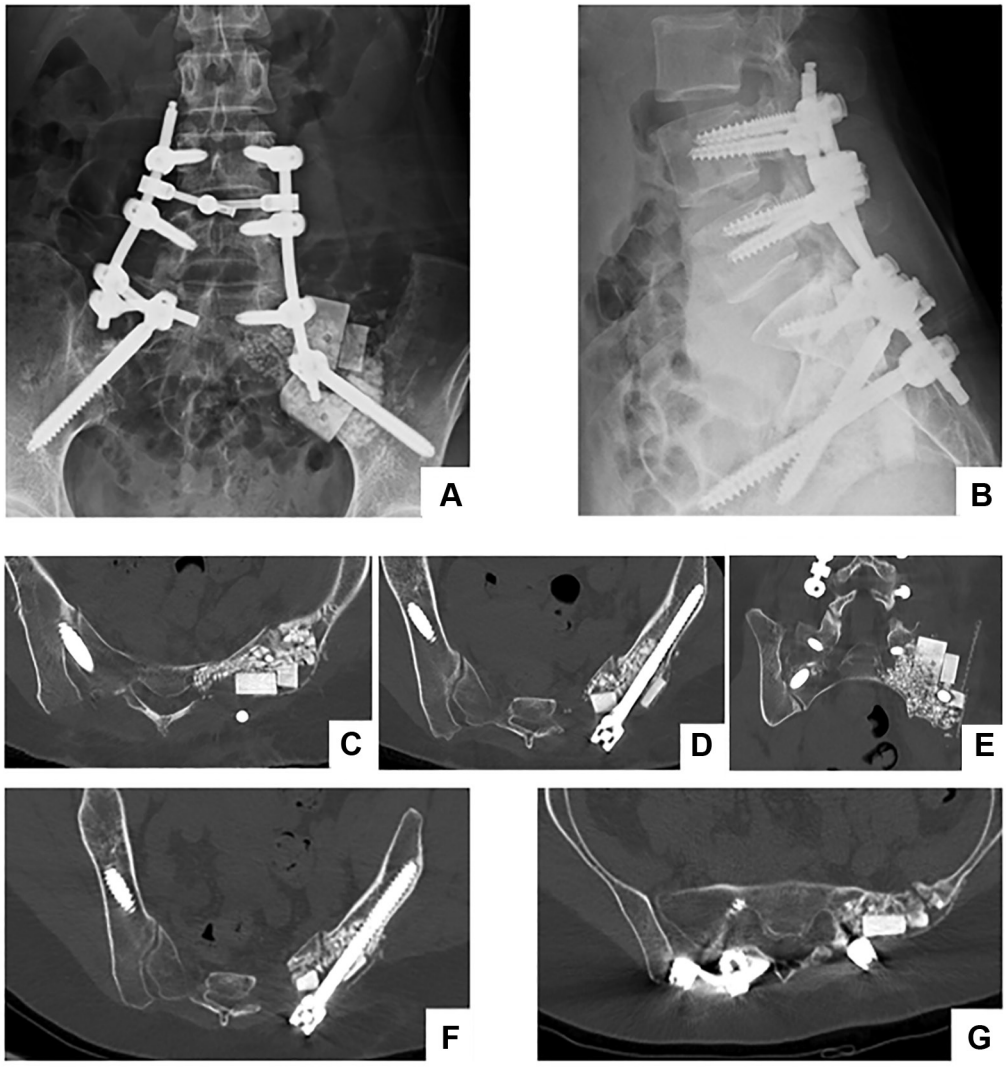



Figure 4. *Postoperative and one-year follow-up imaging. A-E) Postoperative radiographs and computed tomography showing stable implant positioning without displacement. The artificial bone graft remains appropriately situated within the defect. F, G) Computed tomography at the one-year follow-up demonstrating no abnormalities in instrumentation or graft position and no evidence of local recurrence.*

ossification, reduces tumor vascularity, and decreases soft-tissue extension, thereby facilitating a safer and more controlled resection (11, 12). However, the optimal duration of therapy remains a matter of debate. While several studies suggest that three to four months of treatment may be sufficient to achieve meaningful ossification (13, 14), our patient received eight months of therapy, resulting in extensive peripheral sclerosis that contributed to a safer dissection around the S1-S3 nerve roots.

However, concerns have been raised regarding the potential for increased local recurrence following prolonged preoperative denosumab treatment (13, 15). Proposed mechanisms for increased recurrence include obscured tumor margins due to dense ossification and the persistence of viable stromal cells within the mineralized matrix (15, 16). Nevertheless, evidence regarding the incidence of recurrence is limited by heterogeneity in treatment protocols, surgical approaches, and follow-up durations. In the present case,

preoperative imaging and analysis of frozen sections prepared from tissue taken intraoperatively ensured adequate margins despite the extensive ossification.

Here, the decision to extend preoperative denosumab therapy was individualized based on two key considerations: (i) the patient's young age, which favored preservation of native bone and avoidance of overly aggressive resection, and (ii) the need to maximize ossification to facilitate safer manipulation of the tumor adjacent to critical neural structures (12, 17). This approach aligns with contemporary European Musculoskeletal Oncology Society recommendations, which emphasize tailoring denosumab treatment duration to tumor location, resectability, and patient-specific factors (18).

*Postoperative denosumab and recurrence prevention.* The role of postoperative denosumab treatment remains unclear. In this case, postoperative therapy was not administered because complete resection was achieved. Although emerging evidence suggests that postoperative denosumab may reduce recurrence risk, its use must be balanced against potential adverse effects, particularly in young women with potential to become pregnant in the future (19, 20). Moreover, recurrence has been reported even after postoperative denosumab treatment is discontinued, and the optimal duration and patient selection criteria remain undefined (20). Thus, withholding postoperative denosumab in this patient was appropriate.

In addition, local recurrence rates for GCTB vary widely (10-50%), depending on tumor location, surgical technique, and margin adequacy (1, 2). Pelvic and sacral lesions exhibit particularly high recurrence rates (34-54% in some studies), reflecting the difficulty of achieving wide margins in these anatomically complex regions (5, 6, 21). Further, intralesional curettage is associated with significantly higher recurrence rates than en bloc resection (22, 23). In this case, en bloc resection with negative margins likely contributed to the favorable early outcome.

*Surgical strategy and reconstruction.* A variety of surgical strategies have been described for pelvic GCTB, including intralesional curettage, en bloc resection, reconstruction with autologous bone grafts, pelvic ring reconstruction using implants, and more recently, patient-specific 3D-printed implants (22, 24-26). Although curettage may provide superior functional outcomes, it carries a high risk of recurrence, particularly in the pelvis. Therefore, wide resection followed by reconstruction is often recommended for lesions with extensive bone destruction.

Additional reconstruction options include metallic implants, autologous grafts, and artificial bone substitutes (27). However, pelvic reconstruction is technically demanding and associated with substantial morbidities such as infection, nonunion, implant loosening, and mechanical failure (28). In addition, some studies have reported that reconstruction does not always result in significantly improved functional outcomes compared with non-reconstructive approaches (28, 29). Nevertheless, reconstruction is essential when acetabular involvement, pelvic discontinuity, or spinopelvic instability is anticipated, as failure to reconstruct these tissues can lead to severe functional impairment (30).

In the present case, the tumor involved the left sacroiliac joint, and en bloc resection was expected to compromise pelvic ring stability. Therefore, reconstruction was necessary. The bone defect was filled with an artificial bone graft and reinforced with a synthetic mesh to prevent graft migration. Screws were placed into all available host bone to maximize fixation strength, and spinopelvic fixation from L4 to the ilium was performed. At the one-year follow-up, no implant loosening or mechanical failure was observed, indicating satisfactory construct stability.

*Long-term follow-up and surveillance.* GCTB is known for its potential to recur many years after initial treatment, necessitating long-term surveillance (1, 2, 4). Although most recurrences occur within the first two to three years, late recurrences beyond 10 years have been reported (4, 31). Standard surveillance protocols typically include clinical evaluation and imaging every three to six months

for the first two years, followed by annual assessments thereafter (31). Although no recurrence was detected at the one-year follow-up in this case, continued close monitoring remains essential.

In addition, malignant transformation of GCTB into high-grade sarcoma can occur; although, it is rare (<5%) and most commonly associated with prior radiotherapy (2, 32). However, primary malignant GCTB is exceedingly uncommon. No features of malignant transformation were observed in this patient, and avoidance of radiotherapy was appropriate (32).

## Conclusion

This case demonstrates that sacroiliac joint GCTB can be effectively managed with preoperative denosumab treatment, posterior en bloc resection, and spinopelvic reconstruction, achieving excellent early tumor control and functional recovery. Tumor ossification induced by denosumab administration facilitated safe resection, although the optimal duration of therapy requires further clarification. Key technical factors, including complete tumor removal, stable implant-based sacroiliac reconstruction, and the use of a synthetic bone graft, contributed to the favorable outcome in this case. Given the variable recurrence patterns of pelvic GCTB, long-term surveillance remains essential. Further multicenter studies are needed to refine perioperative denosumab treatment protocols and surgical strategies for this rare and challenging tumor.

## Conflicts of Interest

The Authors declare that they have no conflicts of interest in relation to this study.

## Authors' Contributions

This study was designed by S.I., I.T., I.Y., K.T., S.N. and K.H. The experiments were performed by S.I., I.T., I.Y, K.T., S.N, K.H. and K.G. The data were analyzed by S.I., I.T., I.Y., K.T., S.N. and K.H. and the results were critically examined by all authors. S.I. had a primary role in preparing the manuscript, which was edited by S.I., I.T., I.Y., K.T., S.N., K.H. and K.G. All Authors have approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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## Artificial Intelligence (AI) Disclosure

During the preparation of this manuscript, a large language model [ChatGPT (OpenAI, San Francisco, CA, USA)] was used solely for language editing and stylistic improvements in select paragraphs. No sections involving the generation, analysis, or interpretation of research data were produced by generative AI. All scientific content was created and verified by the authors. Furthermore, no figures or visual data were generated or modified using generative AI or machine learning–based image enhancement tools.

## References

1 Rekhi B, Dave V: Giant cell tumor of bone: an update, including spectrum of pathological features, pathogenesis, molecular profile and the differential diagnoses. Histol Histopathol 38(2): 139-153, 2023. DOI: 10.14670/HH-18-486

2 Jha Y, Chaudhary K: Giant cell tumour of bone: a comprehensive review of pathogenesis, diagnosis, and treatment. Cureus 15(10): e46945, 2023. DOI: 10.7759/cureus.46945

3 van der Linde RM, van IJzendoorn DGP, van de Rijn M, Bovée JVMG: Giant cell-rich tumors of bone and soft tissue. Mod Pathol 39(1): 100915, 2026. DOI: 10.1016/j.modpat.2025.100915

4 Domovitov SV, Chandhanayingyong C, Boland PJ, McKeown DG, Healey JH: Conservative surgery in the treatment of giant cell tumor of the sacrum: 35 years' experience. J Neurosurg Spine 24(2): 228-240, 2016. DOI: 10.3171/2015.4.SPINE13215

5 Leggon RE, Zlotecki R, Reith J, Scarborough MT: Giant cell tumor of the pelvis and sacrum. Clin Orthop Relat Res 423: 196-207, 2004. DOI: 10.1097/01.blo.0000128643.38390.07

6 Shen CC, Li H, Shi Z, Tao H, Yang Z: Current treatment of sacral giant cell tumour of bone: a review. J Int Med Res 40(2): 415-425, 2012. DOI: 10.1177/147323001204000203

7 Atkins GJ, Haynes DR, Graves SE, Evdokiou A, Hay S, Bouralexis S, Findlay DM: Expression of osteoclast differentiation signals by stromal elements of giant cell tumors. J Bone Miner Res 15(4): 640-649, 2000. DOI: 10.1359/jbmr.2000.15.4.640

8 Mak IW, Evaniew N, Popovic S, Tozer R, Ghert M: A translational study of the neoplastic cells of giant cell tumor of bone following neoadjuvant denosumab. J Bone Joint Surg Am 96(15): e127, 2014. DOI: 10.2106/JBJS.M.01332

9 Thomas D, Henshaw R, Skubitz K, Chawla S, Staddon A, Blay JY, Roudier M, Smith J, Ye Z, Sohn W, Dansey R, Jun S: Denosumab in patients with giant-cell tumour of bone: an open-label, phase 2 study. Lancet Oncol 11(3): 275-280, 2010. DOI: 10.1016/S1470-2045(10)70010-3

10 Chawla S, Henshaw R, Seeger L, Choy E, Blay JY, Ferrari S, Kroep J, Grimer R, Reichardt P, Rutkowski P, Schuetze S, Skubitz K, Staddon A, Thomas D, Qian Y, Jacobs I: Safety and efficacy of denosumab for adults and skeletally mature adolescents with giant cell tumour of bone: interim analysis of an open-label, parallel-group, phase 2 study. Lancet Oncol 14(9): 901-908, 2013. DOI: 10.1016/S1470-2045(13)70277-8

11 Rutkowski P, Ferrari S, Grimer RJ, Stalley PD, Dijkstra SP, Pienkowski A, Vaz G, Wunder JS, Seeger LL, Feng A, Roberts ZJ, Bach BA: Surgical downstaging in an open-label phase II trial of denosumab in patients with giant cell tumor of bone. Ann Surg Oncol 22(9): 2860-2868, 2015. DOI: 10.1245/s10434-015-4634-9

12 Nishimura S, Hashimoto K, Tan A, Yagyu Y, Akagi M: Successful treatment with denosumab in a patient with sacral giant cell tumor of bone refractory to combination therapy with arterial embolization and zoledronic acid: A case report. Mol Clin Oncol 6(3): 307-310, 2017. DOI: 10.3892/mco.2017.1137

13 Chen X, Li H, Zhu S, Wang Y, Qian W: Pre-operative denosumab is associated with higher risk of local recurrence in giant cell tumor of bone: a systematic review and meta-analysis. BMC Musculoskelet Disord 21(1): 256, 2020. DOI: 10.1186/s12891-020-03294-2

14 Niu X, Zhang Q, Hao L, Ding Y, Li Y, Xu H, Liu W: Giant cell tumor of the extremity: retrospective analysis of 621 Chinese patients from one institution. J Bone Joint Surg Am 94(5): 461-467, 2012. DOI: 10.2106/JBJS.J.01922

15 Hindiskere S, Errani C, Doddarangappa S, Ramaswamy V, Rai M, Chinder PS: Is a short-course of preoperative denosumab as effective as prolonged therapy for giant cell tumor of bone? Clin Orthop Relat Res 478(11): 2522-2533, 2020. DOI: 10.1097/CORR.0000000000001285

16 Nagano A, Urakawa H, Tanaka K, Ozaki T: Current management of giant-cell tumor of bone in the denosumab era. Jpn J Clin Oncol 52(5): 411-416, 2022. DOI: 10.1093/jjco/hyac018

17 Kamath N, Agarwal J, Gulia A: Axial giant cell tumor - current standard of practice. J Clin Orthop Trauma 10(6): 1027-1032, 2019. DOI: 10.1016/j.jcot.2019.09.025

18 Casali PG, Bielack S, Abecassis N, Aro HT, Bauer S, Biagini R, Bonvalot S, Boukovinas I, Bovee JVMG, Brennan B, Brodowicz T, Broto JM, Brugières L, Buonadonna A, De Álava E, Dei Tos AP, Del Muro XG, Dileo P, Dhooge C, Eriksson M, Fagioli F, Fedenko A, Ferraresi V, Ferrari A, Ferrari S, Frezza AM, Gaspar N, Gasperoni S, Gelderblom H, Gil T, Grignani G, Gronchi A, Haas RL, Hassan B, Hecker-Nolting S, Hohenberger P, Issels R, Joensuu H, Jones RL, Judson I, Jutte P, Kaal S, Kager L, Kasper B, Kopeckova K, Krákorová DA, Ladenstein R, Le Cesne A, Lugowska I, Merimsky O, Montemurro M, Morland B, Pantaleo MA, Piana R, Picci P, Piperno-Neumann S, Pousa AL, Reichardt P, Robinson MH, Rutkowski P, Safwat AA, Schöffski P, Sleijfer S, Stacchiotti S, Strauss SJ, Sundby Hall K, Unk M, Van Coevorden F, van der Graaf WTA, Whelan J, Wardelmann E, Zaikova O, Blay JY, ESMO Guidelines Committee, PaedCan and ERN EURACAN: Bone sarcomas: ESMO–PaedCan–EURACAN Clinical Practice Guidelines for diagnosis, treatment and follow-up. Ann Oncol 29(Suppl 4): iv79-iv95, 2018. DOI: 10.1093/annonc/mdy310

19 Vaishya R, Pokhrel A, Agarwal AK, Vijay V: Current status of bone cementing and bone grafting for giant cell tumour of bone: a systemic review. Ann R Coll Surg Engl 101(2): 79-85, 2019. DOI: 10.1308/rcsann.2019.0004

20 Matcuk GR Jr, Patel DB, Schein AJ, White EA, Menendez LR: Giant cell tumor: rapid recurrence after cessation of long-term denosumab therapy. Skeletal Radiol 44(7): 1027-1031, 2015. DOI: 10.1007/s00256-015-2117-5

21 Tsukamoto S, Mavrogenis AF, Kido A, Errani C: Current concepts in the treatment of giant cell tumors of bone. Cancers (Basel) 13(15): 3647, 2021. DOI: 10.3390/cancers13153647

22 Balke M, Streitbuerger A, Budny T, Henrichs M, Gosheger G, Hardes J: Treatment and outcome of giant cell tumors of the pelvis. Acta Orthop 80(5): 590-596, 2009. DOI: 10.3109/17453670903350123

23 Yacob O, Umer M, Gul M, Qadir I: Segmental excision versus intralesional curettage with adjuvant therapy for giant cell tumour of bone. J Orthop Surg 24(1): 88-91, 2016. DOI: 10.1177/230949901602400120

24 Hernandez CL, Díaz SM, Nurmukhametov R, Goncharov E, Ramirez MJE, Bozkurt I, Ramirez Pena IJ: A case report of a sacral giant cell tumor treated with block resection and lumbo-pelvic fixation. Cureus 14(11): e31224, 2022. DOI: 10.7759/cureus.31224

25 Agulnick M, Cohen BR, Epstein NE: Reconstruction of shattered lumbo-sacral junction/pelvis utilizing bilateral L4-sacrum fibula strut allograft and double iliac screws plus

routine lumbar pedicle screw fixation. Surg Neurol Int 11: 335, 2020. DOI: 10.25259/SNI_326_2020
26 Hu D, Song F, Xiao S: Total resection of sacral giant cell tumor with en bloc resection, sacral nerve reconstruction, and custom 3D-printed implant: a case report with long-term follow-up. Int J Surg Case Rep 130: 111293, 2025. DOI: 10.1016/j.ijscr.2025.111293
27 Ogura K, Sakuraba M, Miyamoto S, Fujiwara T, Chuman H, Kawai A: Pelvic ring reconstruction with a double-barreled free vascularized fibula graft after resection of malignant pelvic bone tumor. Arch Orthop Trauma Surg 135(5): 619-625, 2015. DOI: 10.1007/s00402-015-2197-7
28 Zheng K, Wang Z, Wu SJ, Ye ZM, Xu SF, Xu M, Hu YC, Yu XC: Giant cell tumor of the pelvis: a systematic review. Orthop Surg 7(2): 102-107, 2015. DOI: 10.1111/os.12174
29 Jin T, Liu W, Xu H, Li Y, Hao L, Niu X: How does iliosacral bone tumor resection without reconstruction affect the ipsilateral hip joint? BMC Musculoskelet Disord 19(1): 102, 2018. DOI: 10.1186/s12891-018-2023-9
30 Han I, Lee YM, Cho HS, Oh JH, Lee SH, Kim HS: Outcome after surgical treatment of pelvic sarcomas. Clin Orthop Surg 2(3): 160-166, 2010. DOI: 10.4055/cios.2010.2.3.160
31 Pitsilos C, Givissis P, Papadopoulos P, Chalidis B: Treatment of recurrent giant cell tumor of bones: a systematic review. Cancers (Basel) 15(13): 3287, 2023. DOI: 10.3390/cancers15133287
32 Heck RK Jr, Stacy GS, Flaherty MJ, Montag AG, Peabody TD, Simon MA: A comparison study of staging systems for bone sarcomas. Clin Orthop Relat Res 415: 64-71, 2003. DOI: 10.1097/01.blo.0000093898.12372.6c