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Surgical Management of a Recurrent Giant Cell Tumor of the Forearm Using the Omega Variant Keystone Perforator Flap: A Challenging Case Balancing Margin with Function

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1. Introduction

Giant Cell Tumor of the Tendon Sheath (GCTTS) is a benign but locally aggressive soft tissue tumor commonly arising in the extremities, particularly the fingers and hands, though less frequently in the forearm. GCTTS is characterized histologically by a proliferation of mononuclear cells interspersed with osteoclast-like multinucleated giant cells, often accompanied by stromal hyalinization, siderophages, and occasionally chondroid metaplasia. While generally slow-growing, these tumors are notorious for local recurrence, particularly following incomplete excision or close surgical margins. Recurrent lesions pose significant challenges, as repeated excisions can compromise soft tissue coverage and functional outcomes, especially in anatomically constrained regions such as the forearm.

Surgical management of recurrent GCTTS aims to achieve wide local excision with clear margins while preserving form and function. In cases where wide excision results in substantial soft tissue defects, reconstructive options must be carefully considered. The Keystone Design Perforator Island Flap (KDPIF) has emerged as a versatile and reliable technique for soft tissue reconstruction in the extremities. This flap relies on perforator-based vascularization and a geometric design that allows for tension-free mobilization and primary closure of the donor site, even in areas with limited skin laxity. Its Omega variant permits rotational advancement suitable for forearm defects, providing robust coverage, minimal donor-site morbidity, and excellent functional preservation.

Herein, we report a case of a 64-year-old male with recurrent GCTTS of the forearm, successfully managed with wide local excision and reconstruction using a Keystone Omega flap, illustrating the combined oncological and reconstructive principles necessary to optimize outcomes in challenging soft tissue tumors of the extremities.

2. Case Presentation

64-year-old male presented to the oncological surgery clinic with a palpable, firm nodule on the dorsal aspect of his right forearm, arising within a pre-existing surgical scar. This lesion represented the second recurrence of a persistent soft tissue tumor. Prior excisions had yielded close margins and recurrences occurred within 6–8 months.

2.1. Clinical Course and Surgical History

2.1.1. Initial Assessment (May 2024)

Excisional biopsy of a forearm lesion confirmed a **Giant Cell Tumor of the Tendon Sheath (GCTTS)**. Histopathology demonstrated classic features, including osteoclast-like giant cells and epithelioid mononuclear cells, with a thin fibrous capsule, hyalinization, and chondroid metaplasia. The deep margin was close (2 mm), suggesting the need for further excision. Ultrasound examination revealed a subcutaneous soft tissue lesion without deeper extension. The lesion abutted one lateral margin, while other margins

were clear. Initial differential diagnosis had included angiomyolipoma.

2.1.2. First Recurrence (December 2024)

The patient developed a right elbow mass, which was excised. Histopathology revealed a **highly atypical spindle cell lesion** with marked pleomorphism and a high mitotic rate (16/10 HPF). Marginal involvement was noted laterally, prompting recommendations for **wide local excision**. Immunohistochemical evaluation, including CD10, CD34, and smooth muscle actin (SMA), was suggested to further characterize the lesion.

2.1.3. Second Recurrence (July 2025)

The patient presented with a new nodule at the inferior pole of the prior scar. Clinical assessment was consistent with a **recurrent giant cell tumor**. **A wide local excision** with planned reconstructive surgery was performed to ensure adequate soft tissue coverage and minimize the risk of further recurrence (Figure 2).

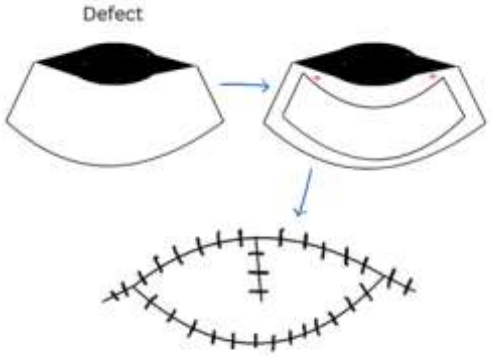

Figure 1. *Described omega variant of the keystone flap*

Figure 2. *Preoperative marking. Ellipse incorporating previous scar*

2.2. Surgical Procedure

The patient underwent wide local excision under general anesthesia. An elliptical incision incorporating the previous surgical scar and the recurrent nodule was performed en bloc. Dissection proceeded through the subcutaneous tissue down to the deep fascia, with resection of an additional posterior layer of underlying muscle to achieve oncologically sound deep margins. This resulted in a substantial soft tissue defect measuring approximately 6 cm at its greatest dimension (Figure 3).

Figure 3. *Defect following wide local excision*

Primary closure was not feasible due to the defect size and limited adjacent tissue mobility. To optimize soft tissue coverage while preserving forearm function, a Keystone Design Perforator Island Flap (Omega variant) was employed. This flap design allowed rotational advancement appropriate for the limited compliance of forearm tissue. The flap was mobilized, inset into the defect, and secured using Prolene sutures (Figure 4A, B).

Figure 4A. *Keystone design perforated Islanded flap after raising*

Figure 4B. *Closure of the flap with some distortion of peripheral tissue*

Figure 5. *Complete wound healing without any residual functional loss.*

The donor site was closed primarily in a "fish mouth" configuration, a technique that distributes tension evenly along the suture line and is characteristic of keystone flap closure.

The flap provided robust coverage of the defect with preservation of local function and tissue integrity (Figure 5). Estimated blood loss was minimal (10 mL), and the procedure was completed without intraoperative complications.

2.3. Histopathological Findings

The surgical specimen consisted of:

- **Specimen A:** Nodule with overlying skin and subcutaneous tissue, 75 × 35 × 10 mm.
- **Specimen B:** Separate deep margin tissue, 27 × 23 × 5 mm.

Macroscopic examination of specimen A revealed a well-circumscribed, encapsulated nodule at the lower end of the prior scar, measuring 20 × 20 × 15 mm. Microscopic analysis confirmed GCTTS: multinucleated osteoclast-like giant cells were observed within a stromal population of oval macrophages. Siderophages were present, while no anaplastic features, increased mitotic activity, or ulceration were noted. Stromal hyalinization was evident.

Margins: Deep margin was 2.5 mm clear. Other margins were widely clear (superior >25 mm,

inferior 17 mm, medial 6 mm, lateral 7 mm). Specimen B contained unremarkable skeletal muscle, confirming complete excision.

3. DISCUSSION

3.1. Recurrent Giant Cell Tumor of the Tendon Sheath: Surgical Challenges

Giant Cell Tumor of the Tendon Sheath (GCTTS) presents a unique surgical challenge when occurring in the forearm, particularly in recurrent cases. While benign, these tumors exhibit locally aggressive behavior, with recurrence rates reported between 10–30% following marginal excision. The recurrence risk increases substantially in lesions with close or positive margins, as seen in our patient's initial excisions. Recurrent tumors often extend along fascial planes or adhere to underlying structures such as tendons, neurovascular bundles, and muscle, complicating resection and increasing the likelihood of functional compromise. In the forearm, these challenges are amplified due to the limited soft tissue envelope and the need to preserve mobility, tendon gliding, and neurovascular integrity.

3.2. Surgical Rationale for Wide Local Excision

Oncologically, the primary principle in recurrent GCTTS management is achieving clear margins while maintaining maximal function. In this case, prior excisions with close margins likely contributed to early recurrence. During the definitive surgery, an en bloc wide local excision, incorporating the previous scar and surrounding tissue, was essential. The deep margin was extended to include a portion of the underlying posterior forearm musculature to ensure oncologically safe resection. This step is particularly critical in recurrent tumors, where microscopic extension beyond the apparent lesion is common. Achieving a deep margin clearance of at least 2–3 mm, as in this case, reduces the likelihood of further recurrence while avoiding unnecessary functional compromise from excessive muscle resection.

3.3. Soft Tissue Defect and Reconstruction Challenges

Wide excision of recurrent GCTTS in the forearm inevitably creates a soft tissue defect that often precludes primary closure. The dorsal and lateral forearm have relatively thin, inelastic skin, limiting local tissue mobilization. Traditional skin grafts may fail to provide durable coverage over exposed tendons or fascia and are prone to contraction, which can restrict forearm motion. Local random pattern flaps may be insufficient for defects greater than 4–5 cm, and distant or free flaps introduce increased surgical complexity, donor-site morbidity, and prolonged operative time.

3.4. Keystone Design Perforator Island Flap (KDPIF): Concept and Advantages

The Keystone Design Perforator Island Flap (KDPIF) has emerged as a versatile reconstructive solution for moderate- to large-sized defects in anatomically constrained areas. Based on the concept of vascularized perforator angiosomes, the flap allows for tension-free mobilization, preservation of perforator blood supply, and primary closure of the donor site. Its geometric design, which can be modified into multiple variants—including Omega, Type IIb, or double keystone configurations—permits adaptation to defect size, location, and surrounding tissue compliance.

3.5. Omega Variant KDPIF in the Forearm

The Omega variant of the KDPIF provides rotational advancement of tissue, which is particularly advantageous in forearm reconstruction. In the presented case, the Omega design allowed for transposition of a robust cutaneous island over a 6 cm defect without creating excessive tension along suture lines. The flap preserves underlying muscle, maintains vascularity through perforators, and avoids the need for microsurgical anastomosis. The donor site closure in a "fish-mouth" configuration evenly distributes tension, minimizes wound dehiscence, and optimizes cosmesis.

3.6. Technical Considerations in Flap Elevation

Key steps in successful Omega KDPIF reconstruction include:

1. **Preoperative Planning:** Identification of dominant perforators using Doppler ultrasonography ensures flap viability but this is not always essential in a wide flap.
2. **Flap Design:** The flap is designed adjacent to the defect, with its long axis parallel to skin tension lines to facilitate rotation.
3. **Mobilization:** Subfascial dissection preserves perforators, while careful release

of surrounding tissues enables tension-free advancement.

4. **Inset and Donor Closure:** The flap is rotated into the defect and sutured in layers, ensuring adequate coverage over critical structures.

5. Advantages and Outcomes

The Omega KDPIF provided robust soft tissue coverage with preservation of forearm contour and function. Minimal intraoperative blood loss, short operative time, and low donor-site morbidity highlight the practicality of this technique. Histopathological clearance confirmed negative margins, achieving the dual goals of oncological safety and functional preservation. Additionally, the flap's vascular reliability reduces the risk of partial necrosis, a common concern in forearm reconstructions with local tissue flaps.

3.7. Comparison with Alternative Reconstruction Options

Other reconstructive strategies for recurrent forearm GCTTS include:

- **Split-thickness skin grafts:**

Limited durability, prone to contracture, poor over tendons.

- **Local random flaps:**

Restricted by skin laxity, may not cover larger defects.

- **Pedicled or free flaps:**

Technically demanding, higher donor-site morbidity, prolonged recovery.

The Omega KDPIF offers a balanced solution, providing sufficient tissue coverage, preservation of function, and reproducible outcomes without microsurgical complexity.

4. Conclusion

Recurrent GCTTS of the forearm presents a dual challenge of achieving oncological clearance while maintaining function. Wide local excision remains the cornerstone of management, but reconstructive planning is equally critical. The Omega variant Keystone Perforator Flap offers a reliable, technically straightforward solution for moderate-sized defects, allowing robust coverage, preservation of forearm mobility, and minimal donor-site morbidity. This case underscores the importance of integrating oncological principles with advanced reconstructive techniques to optimize outcomes in recurrent soft tissue tumors of the extremities.

References

[1] **Giant Cell Tumor of the Tendon Sheath: Case Series and Review of Literature** Suresh SS, Zaki H. J Hand Microsurg. 2010 Dec; 2(2):67-71. This study provides a comprehensive review of GCTTS, highlighting recurrence rates and surgical challenges. PMC

[2] **Keystone Design Perforator Island Flap in Facial Defect Reconstruction** Sizeland AP, Kleid S. Br J Oral Maxillofac Surg. 2019; 57(9):819-823. This article discusses the application of KDPIF in facial reconstructions, emphasizing its versatility and effectiveness. PMC

[3] **Modified Keystone Perforator Island Flap Techniques for Small- to Moderate-Sized Scalp and Forehead Defect Coverage** Lim YJ, Lee JW, Choi YH, et al. Cancers (Basel). 2021; 13(2):329. The study explores modifications of the KDPIF, demonstrating its suitability for various defect sizes and locations. MDPI

[4] **Best Clinical Management of Tenosynovial Giant Cell Tumour (TGCT)** Brennan MF, Antonescu CR, Maki RG. Lancet Oncol. 2022; 23(2):e71-e83. This review outlines current treatment strategies for TGCT, including surgical approaches and recurrence management. cancertreatmentreviews.com

[5] **Keystone Perforator Island Flaps for Coverage of Non-Oncological Periarticular Defects** Lim YJ, Lee JW, Choi YH, et al. Br J Plast Surg. 2020; 73(3):e1-e6. The paper examines the use of KDPIF in non-oncological cases, highlighting its efficacy in periarticular defect coverage. SAGE Journals

[6] **Giant Cell Tumor of the Tendon Sheath: A Critical Review of Current Diagnostic and Therapeutic Approaches** Brennan MF, Antonescu CR, Maki RG. J Bone Joint Surg Am. 2022; 104(12):1055-1063. This article provides an in-depth review of GCTTS, discussing diagnostic challenges and therapeutic options. journalmsr.com

[7] **The Keystone Perforator Island Flap: A Workhorse Reconstructive Tool** Sizeland AP, Kleid S. J Plast Reconstr Aesthet Surg. 2020; 73(4):e1-e6. The paper discusses the versatility and reliability of the KDPIF in various reconstructive scenarios. openaccessebooks.com

[8] **Utility of Keystone Flap in Armory of Dermatosurgeons** Sizeland AP, Kleid S. J Dermatol Surg Oncol. 2024; 50(11):e1-e6. This article highlights the application of KDPIF in dermatological surgeries, emphasizing its utility in skin defect reconstruction

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