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Functional Outcomes of Aggressive Giant Cell Tumours of Distal End Radius Managed with Wide Resection & Proximal Fibular Reconstruction

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Abstract
Introduction: *Giant cell tumour (GCT) of distal end radius is a locally aggressive tumour with high tendency for recurrence. As compared to intralesional procedures, wide resection has been uniformally reported to have better results. The defect created by resection can be reconstructed using various modalities, such as vascularized/non-vascularized bone grafts, osteoarticular allografts, custom made prosthesis etc. We studied the outcomes of wide resection and reconstruction with non-vascularized fibular autograft as management of biopsy proven giant cell tumours of distal end radius.*
Material & Methods: *13 patients with giant cell tumour distal end radius (Campanacci Grade 3) were treated during a period from 2010 to 2017 at our institution by wide excision and bone grafting using non-vascularised fibula followed by iliac crest bone grafting at the radio-fibular junction.*
Results: *Mean follow-up duration was 74.31 months (60-84 months). At last follow-up, the average combined range of motion was 154.6° (supination, pronation, dorsifl exion, palmar flexion, ulnar deviation and radial deviation) with range varying from 120° to 180°. Mean functional score was 92.61 (83-96) as per modified system of the Musculoskeletal Tumour Society. The average union time was 6.25 months (range 4 to 9 months). Delayed union was encountered in 1 case & graft resorption in 1 case.*
Conclusion: *Non- vascularised proximal fibular reconstruction after wide excision of the tumour appears to be the most reliable technique for GCT of distal end radius as it preserves movements, stabilizes the wrist and provides good functional outcomes.*
Keywords: *Giant cell tumour; Distal end radius; Fibula reconstruction; wide resection; Locally aggressive*

Introduction

Giant cell tumour (GCT) of bone is a locally aggressive tumour with high tendency for local recurrence.[1] It presents in 3rd and 4th decade of life with a definite female preponderance.[2] After distal femur and proximal tibia, distal radius happens to be the most common site of occurrence for GCT.[2,3] This site has a further distinction of having more locally aggressive tumour of GCT with high chances of recurrences and malignant transformation.[4,5]

GCT shows variable clinical behaviour that is often unrelated to its radiological and histological appearance. Presentation may be pain with or

without swelling at the wrist. Magnetic resonance imaging helps in diagnosis and histological examination of the biopsy specimen will confirm the true nature of the lesion. Selection of proper treatment is complicated by the failure of its histological appearance to indicate its biologic behaviour.[6]

GCT distal end of the radius presents special problems in local control of the tumour and reconstruction after surgical treatment because of limited surrounding soft tissue, closeness to adjacent neurovascular structures, and juxta-articular location. These tumours have more aggressive behaviour and high recurrence rate for both intra-lesional and excisional procedures.[7] Complete excision of the tumour provides the best chance of cure but sacrificing the articular surface presents complex reconstructive problems which may lead to complications, repeated surgeries and poor functional outcome.

The goal of treatment is to remove the tumour completely while preserving maximum function of the extremity. Surgical intervention includes curettage and adjuvant treatment followed by reconstruction of the osseous defect with bone graft or methylmetacrylate cement or en bloc excision and reconstruction with non vascular or vascular fibular autograft, osteoarticular allograft, ulnar translocation, or endoprosthesis.

Many studies report high rates of local recurrence (23-80%) in GCT distal end radius treated by curettage, with or without bone grafting.[8-10] While packing the cavity created after removal of tumour provides structural support, it has been criticised for obscuring the possible local recurrence of the neoplasm.[11-13]

A lower rate of local recurrence has been noted after resection of the diseased bone; but a complex reconstruction procedure (arthroplasty) or arthodesis of the wrist is required.[14-16] Other procedures that may be employed to reconstruct the defect include vascularised or non-vascularised bone graft from tibia or proximal fibula[17-19], osteo-articular allograft[20], and transposition of the carpus & custom made prosthesis.[10] All these procedures have certain morbidity and complications associated with them; nevertheless, resection and reconstruction may be the only option in cases of aggressive tumours with cortical erosions.

Enneking[14] attributed the high incidence of local recurrence to the indiscriminate use of the curettage for all grades of the tumour. As compared to intralesional procedures, wide resection has been uniformally reported to have a better result as far as local recurrence of the tumour is concerned.[21,22]

There are very limited reports on reconstruction with use of prostheses and long-term results are yet to be validated.[23] Arthrodesis and translocation of carpus would result in loss of motion.[24] Reconstruction using vascularized fibular graft is highly specialized and is not possible at all centers.[25,26] An alternative procedure described was the use of autologous non-vascularised fibula. We studied the outcomes of wide resection and reconstruction with non-vascularized fibular autograft as management of biopsy proven giant cell tumours of distal end radius.

Material and Methods

13 patients with locally aggressive GCT distal end of the radius were treated and followed up from 2010 to 2019 at our institution. There were 6 male and 7 female patients. Average age of presentation was 29.3 yrs (range 21-45 yrs). The average follow-up was 74.30 months (range 60-84 months). Provisional diagnosis was done clinically and radiologically with standard x-rays of the wrist. Chest x-ray was also performed in all cases to rule out metastasis. CT scan & MRI of the wrist were performed to localize the extent of the tumour and involvement of the soft tissue. Patients were categorized using a Campanacci's radiological grading method.[7] We included only Campanacci Grade III tumours in our study, characterized by fuzzy borders, suggesting a rapid, and possibly a permeative growth. The diagnosis was confirmed by histolo-pathology of the biopsy specimen in all the cases. There was no

evidence of metastatic disease in any of the patients at the time of diagnosis. All patients were managed with wide excision followed by autograft reconstruction with contralateral proximal fibula (autogenous free fibular grafting) and contralateral iliac crest bone graft at radio-fibular region. Functional outcomes till final follow-up were documented using the modified musculoskeletal tumour society score (MTSS)

Operative Technique

All patients were operated under general anaesthesia and affected wrist, hand, forearm, contralateral leg and contralateral iliac crest were prepared and draped appropriately. A pneumatic tourniquet was used. A long volar incision (standard Henry's approach) and small dorsal incision (for dorsal capsulotomy so as to minimise chances of wound contamination and pathological fracture) was used in all cases. Biopsy tract, if present, was incorporated in the incision. The neurovascular bundle was carefully preserved. Pronator quadratus was lifted off its insertion into the ulna and was included in the resection along with the interosseous membrane. Dorsally, the extensor tendons were retracted and the distal end of radius was removed extraperiosteally with a rim of surrounding soft tissue taking special care to avoid tumour spillage and pathological fracture. The radius was resected at least 3-5 cm proximal to the extent of the tumour (as a safe margin) as determined by CT and MRI preoperatively. After excision, tumour bed was routinely treated with 5% phenol and 3% hydrogen peroxide to take care of the inadvertent spillage, if any. We tried to avoid resecting all of the radiocarpal ligaments, if not involved, as these were later repaired to ligaments attached to proximal fibula to form a stable wrist joint.

Contralateral fibula was approached from standard direct lateral approach after identifying and carefully protecting the common peroneal nerve. Fibula was sectioned at desired length depending on the defect created in forearm after tumour resection. While freeing the proximal tibiofibular articulation some length of lateral ligaments attached to fibular head were retained with the graft. After resection of the fibular part, lateral collateral ligament and biceps femoris tendon were reattached to tibia through drill holes made for this purpose. Haemostasis was achieved before closing the wound over a suction drain.

The final length of the graft was selected and harvested according to the length of the resected radius. Once that was decided, then the graft was provisionally attached to the radius with help of plate holding clamps and LC-DCP. The wrist was reduced provisionally to assess the final positioning of the graft. The next step was to secure the fibular graft with help of the LC-DCP with at least 3 screws on either side of the docking site. Once done, the wrist was now reduced again and held in position using K-wires of 2/2.5-mm diameter. One wire was passed across the fibular graft and the distal ulna to reconstruct the new distal 'radio-ulnar' joint. The second wire was passed from the new 'distal end radius' (fibular graft) toward the carpus. The third wire was passed from the ulnar head, across the lunate and into the scaphoid. This triangular configuration of the K-wires provided enough stability to keep the wrist in position. The remnant fibular collateral ligament was sutured to the radial collateral ligaments to enhance stability. An iliac crest bone graft from contralateral side was routinely taken and applied at radio-fibular junction. After careful haemostasis, wound was closed over a suction drain and an above elbow slab was applied with the elbow in flexion for a period of 2 months followed by a volar forearm and wrist brace with intermittent mobilization. The lower limb was given a compression bandage postoperatively which was removed on second postoperative day and a light dressing applied. As soon as the patient could, full weight bearing was allowed on operated extremity to pain tolerance. The K-wires were removed at 8 weeks postoperatively. The patients were not permitted to lift any weight for a total period of one year after surgery, the limb being kept supported in a brace till that period.

Clinical & radiological details of two of our cases of aggressive GCT distal end radius are shown in Figure 1 & Figure 2

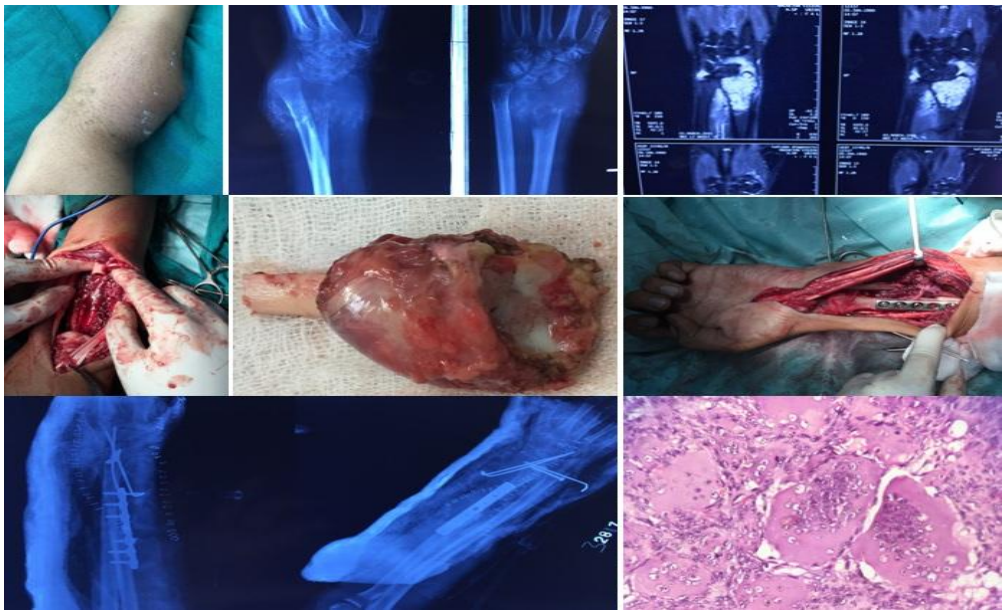

Figure 1) a) Upper row shows pre-operative clinical & radiological images of grade 3 GCT distal end radius in 21yr male. **b)** Middle row shows Intra-operative images of resected tumour & subsequent reconstruction with contralateral proximal fibula. **c)** Lower row shows post-operative x-rays & histology of the tumour. Patient had good outcome

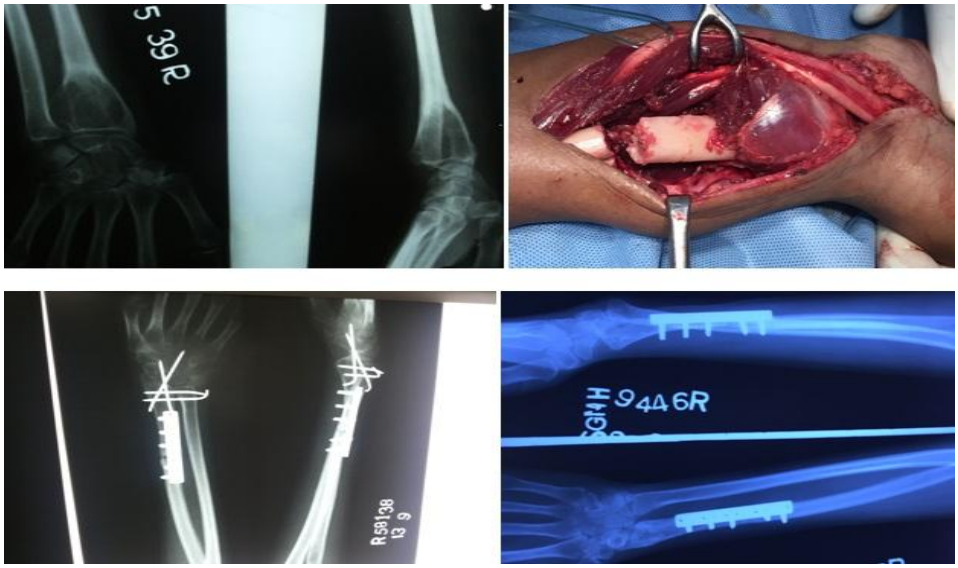

Figure 2) a) Upper half shows pre-operative & intraoperative image in 35yr female with grade 3 GCT distal end radius. **b)** Lower half shows immediate post-op as well as 6 month follow-up x-rays showing radio-fibular union. Patient had an excellent outcome

Follow-up

Patients were followed-up at weekly intervals in the first month, fortnightly for the next 2 months and monthly thereafter. X-rays were taken at every visit after the 8 weeks. The aim of the early follow-up is to detect local recurrence. Every 3 months, the patients were assessed for local recurrence and surgical complications, if any, including infection, implant failure, nonunion, fracture. Residual pain and ability to perform activities daily living were also documented. The minimum period of follow up was 5 years.

Functional results were documented using the modified musculoskeletal tumour society score

(MTSS) which utilizes factors (pain, functional activities, and emotional acceptance) pertinent to the patient as a whole as well as specific to the upper limb (positioning of hand, manual dexterity, and lifting ability)[28]. Results were established as excellent for MSTS score > 90%, good for 80-90%, satisfactory for 60-80% and poor for ≤ 60% score.

Results

There were 6 males and 7 female in our study. Mean age was 29.38 years (range 21-45 years). 9 patients had right-sided involvement and 4 had left-sided. All patients had biopsy proven Campanacci Grade 3 tumours. None of these patients had pathological fracture or any evidence of metastasis. None of the patients had recurrence till last follow up.

Mean follow-up duration was 74.31 months (60-84 months). At last follow-up, the average combined range of motion was 154.6° (supination, pronation, dorsiflexion, palmar flexion, ulnar deviation and radial deviation) with range varying from 120° to 180°. Mean functional score was 92.61 (range 83-96) according to modified system of the Musculoskeletal Tumour Society [28] [Table 1]

The average union time was 6.25 months (range 4 to 9 months). Delayed union was encountered in 1 case. Graft resorption occurred in 1 case which was managed by wrist arthrodesis by using intercalary fibular graft and iliac crest bone graft. No other complications including graft fracture, infection, metastasis, local recurrence or significant donor site morbidity were reported.

Table 1) Case details, follow-up & outcomes of aggressive Grade 3 GCT Distal end radius

SNo.	Age/Sex	FOLLOW-UP (Months)	GRAFT UNION (Months)	FUNCTIONALOUTCOME (MTSS)	ROM (Degrees)	COMPLICATIONS
1	31/F	84	4	96	170	-
2	21/M	72	6	93	160	-
3	27/M	78	8	93	150	-
4	45/F	84	6	96	180	-
5	32/F	72	7	90	150	-
6	25/M	72	5	96	150	-
7	27/F	60	8	83	120	Graft Resorption
8	35/F	60	4	96	180	-
9	30/M	84	6	96	150	-
10	34/F	72	5	96	170	-
11	24/M	84	8	93	150	-
12	25/M	72	7	93	160	-
13	26/F	72	9	83	120	Delayed Union

Discussion

Giant cell tumour is locally aggressive tumour with high rate of recurrence. In 90% of cases the tumour occurs in the epiphysis of the long bones. Only about 8% of all giant cell tumours involve the distal part of the radius.[27]

The goal of treatment is complete eradication of the diseased tissue while preserving normal bony architecture and joint function. One must weigh the extent of the surgical procedure and the subsequent functional deficit against the chance of recurrence. Classically, for small lesions (Campanacci grade I), curettage and bone grafting or cementing to preserve the adjacent wrist joint is preferred. Treatment of grade II and III is controversial. For large aggressive lesions with extensive cortical destruction and soft tissue extension or lesions with pathologic fracture, resection and reconstruction of the distal radius is preferred.[28]

Reconstruction of the large defect created after resection of involved distal radius using contralateral fibular nonvascularised autograft offers many advantages over other procedures. It

has low donor site morbidity, if any, with predictable and satisfactory functional results and is relatively free of major complications although minor complications occur frequently.[21,24,29,30] It offers several advantages like more congruency of carpal joint, rapid incorporation as autograft and easy accessibility. Moreover, immunogenic reactions are absent and bone banking facilities or graft matching procedures are not required.

We managed 13 patients of aggressive Grade 3 giant cell tumour of distal end radius by wide resection followed by reconstruction of the defect by using contralateral non-vascularised fibular strut autograft augmented with contralateral iliac crest cancellous autograft. Graft union occurred in 6.25 months on an average which is comparable to earlier studies.[21,24,30-33] We achieved good to excellent functional results in majority of cases using this technique. The average combined range of motion was 154.6° (supination, pronation, dorsiflexion, palmar flexion, ulnar deviation and radial deviation) with range varying from 120° to 180°. This has been shown in literature to vary from 40° to 77° and 70° to 185°, respectively[31,34] and 80° to 200°.[33] Mean functional score was 92.61 (83-96), as per modified Musculoskeletal Tumour Society score which was comparable to the earlier published studies[32,33,35]

None of the cases showed recurrence till last follow up. No major complication were encountered except graft resorption & delayed union in 1 case each.

Based on our outcomes, non- vascularised proximal fibular grafting after wide excision of the lesion appears to be a reliable technique for GCT of distal radius which gives good to excellent results as it preserves movements and functions as well as stability of wrist. Non-vascularised proximal fibular graft is reasonably congruous with distal radius as well. Its incorporation as an autograft is more rapid and predictable. Moreover, it is easily accessible without significant donor site morbidity. This technique is a reasonable method for managing GCT distal end radius as it provides good functional results without major complication.

Conclusion

Non-vascularised fibular autograft reconstruction of distal radius is an excellent procedure with good functional outcomes after wide resection of locally aggressive (Grade III) GCT of distal end radius. This technique has wide coverage as it does not require availability of bone bank or microvascular surgery.

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