Case Series

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Functional outcome of campanacci grade 3 giant cell tumours of distal radius after resection and reconstruction with ulnar translocation technique: a case series

Muhammad Phetrus Johan, MD PhD[a], Anthony Evans Sukendar, MD[a], Henry Yurianto, MD PhD[a], Leonard Christianto Singjie, MD[a], Mohammad Asri Abidin, MD[b], Jainal Arifin, MD[a], Muhammad Andry Usman, MD[a], Tomohiko Sakuda, MD PhD[c], M. Ruksal Saleh, MD PhD[a]

Background: Reconstruction after en-bloc resection can be challenging in cases of Campanacci grade 3 giant cell tumour of the bone (GCTB) of the distal radius. Here, the authors examined the outcomes of patients with Campanacci grade 3 GCTBs of the distal radius who underwent wrist arthrodesis and reconstruction with ulnar translocation.

Material and methods: This case series was a retrospective single-centre study. Clinical assessments regarding the functional status and complications were follow-up. The functional results were evaluated using the Musculoskeletal Tumor Society (MSTS) and Disability of Arm, Shoulder, and Hand (DASH) Score. Paired *t*-tests were used to compare the MSTS and DASH scores separately before and after the operation. Statistical differences were considered significant at *P* less than 0.05.

Results: Seven patients were included in this study. The mean follow-up period was 14.43 ± 8.08 months. The average length of tumour resection was 9.78 ± 2.88 cm. The average range of motion of the involved forearm was 82.66° of supination and 81.54° of pronation. The average MSTS score was 11.71 ± 2.21 before and 25.14 ± 2.41 after the operation ($P < 0.05$). The average DASH score on admission was 40.14 ± 14.66, which decreased to 9.02 ± 4.23 after the operation ($P < 0.05$). Of the seven cases, one case had a recurrence, and one patient had radioulnar synostosis.

Conclusion: Wrist arthrodesis combined with ulnar translocation can be considered a simple and effective reconstruction method with preservation of function after en-bloc resection of Campanacci grade 3 GCTB of the distal radius. It provides good functional outcomes with low complication rates.

Keywords: campanacci grade 3, case series, distal radius, giant cell tumour of the bone, ulnar translocation

Introduction

Giant cell tumour of the bone (GCTB) accounts for 4–10% of all primary bone tumours and comprises roughly 20% of all benign bone lesions. GCT usually occurs at the epimetaphyseal region of long bones (75–90%), and 10–12% occurs at the distal radius. The distal radius is the third most common site for GCT of the bone, after the distal femur and proximal tibia[1,2].

The main goals of treating distal radial GCTB are to achieve complete tumour removal, retain as much limb function as possible and reduce the chance of local recurrence. Modalities of surgery for treating GCT of the bone range from simple intralesional excision and augmentation of the defect with bone cement to en-bloc resection for the large and extensive tumour with the destruction of the cortex[3–5]. Campanacci grade 3 GCTB involve the adjacent soft tissues following a breach in the cortex. High recurrence rates are observed with an intralesional excision and bone grafting for Campanacci grade 3 lesions. Intralesional excision or curettage has a five-fold rate of recurrence than en-bloc resection and is typically not an option for GCTB involving a break in the cortex[6]. Although wide resection may

HIGHLIGHTS

- Giant cell tumour of the bone distal radius Campanacci grade 3 can be reconstructed with ulnar translocation.
- Significant difference of the functional Musculoskeletal Tumor Society scores were found after operation.
- Significant difference of the functional Disability of Arm, Shoulder, and Hand scores were found after operation.

[a]Department of Orthopaedic and Traumatology, Faculty of Medicine, Hasanuddin University, Dr. Wahidin Sudirohusodo General Hospital, [b]Medical Faculty, Muhammadiyah University, Makassar, Indonesia and [c]Department of Orthopaedic Surgery, Graduate School of Biomedical and Health Sciences, Hiroshima University, Hiroshima, Japan

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*Corresponding author. Address: Department of Orthopaedics and Traumatology, Dr. Wahidin Sudirohusodo General Hospital Faculty of Medicine, Hasanuddin University, Jl. Perintis Kemerdekaan Km 10, Hasanuddin University Hospital 3rd Floor Makassar, 90245, Indonesia. Tel.: (+62) 411-590-190. Fax: (+62) 411590190 E-mail address: muhpjo@gmail.com (M. P. Johan).

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decrease the recurrence rate of GCTB to 16%, it may cause functional impairment postoperatively due to bone defects. Thus, subsequent reconstruction techniques must be prescribed to maximize the functional outcome and increase the quality of life after the operation. Seradge was the first to describe using an ulnar translocation along with its soft tissues as a substitution for the resected distal end of the radius GCTB[1,4,7–9].

The current study aims to investigate the results of Campanacci grade 3 GCTB of the distal radius treated by wide resection and reconstruction using the ulna translocation and wrist arthrodesis.

Material and methods

The present study is a single-centre case series study. We retroscpectively reviewed patients with Campanacci grade 3 GCTB involving the distal radius operated by en-bloc resection of the tumour followed by reconstruction of the gap with translocation of the ipsilateral ulna and arthrodesis of the wrist from medical records and musculoskeletal oncology registries from January 2020 to June 2022. Informed consent was obtained before treatments for all the patients. The study was authorized by the medical ethics committee of our institute and conducted in accordance with the Declaration of Helsinki's ethical standards. All surgeries were performed by two orthopaedics oncology surgeons and one orthopaedic hand microsurgery surgeon. Prior to surgery, all the preoperative evaluations and preparations were carried out in accordance with the standard protocol and optimized accordingly.

Confirmation of diagnosis was by core needle biopsy in all the cases. Evidence of radiographic characteristics of GCT on roentgenogram, MRI, and histological confirmation by biopsy was required for inclusion (Fig. 1). MRI of the wrist was utilized to assess the extent of the lesion, extraosseous part and its relationship to the neurovascular bundle, as well as to determine the amount of bone resection. The patients included in the research were first treated at our institution.

The GCTB of the distal radius and the biopsy scar and pronator quadratus were removed using a dorsal technique. The level of radial bone excision was determined based on MRI results, with 2 cm of normal radius bone designated as a safety margin. The resected radius is submitted for histopathologic evaluation to confirm sufficient margins and the pathologic diagnosis. The bone defect ranged from 6 to 15 cm (mean 9.8 cm). The distal end of the ulna was exposed before being cut along with the triangular fibrocartilage complex and the ulna styloid. A comparable defect is developed in the scapholunate interval in the

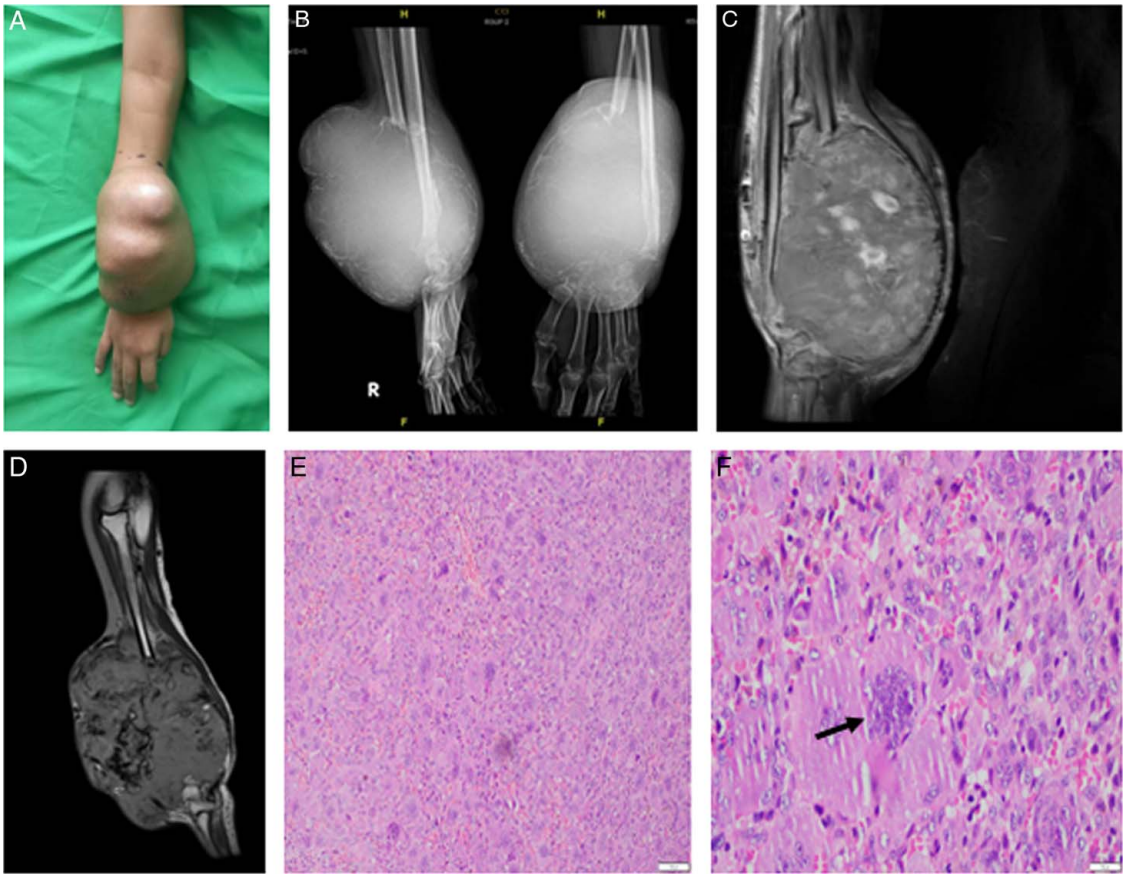

Figure 1. (A) Representative clinical photograph of the forearm of a 21-year-old woman with a lump in her right wrist. (B) X-ray of the forearm and wrist anteroposterior and lateral views revealing an osteolytic lesion with typical expansile features and destruction of the cortex and the distal right radius (grade 3 Campanacci). (C, D) The T2-weighted MRI of the wrist shows cortical breach and soft tissue involvement by the tumour. Microscopic images for histological sample, magnified at 40 μm (E) and 100 μm (F), showed the presence of osteoclast-like giant cells (indicated by a black arrow) that seem dispersed between numerous mononuclear cells, which served as confirmation of the diagnosis of a GCTB. giant cell tumour of the bone.

scaphoid and lunate bone. Confirming the requisite length of the ulna shaft in accordance with the defect created after tumour resection, the ulna shaft is exposed with an intact muscle cuff at the level where the radius was cut. To conserve as much soft tissue attachment as feasible, the dissection of the ulna shaft is performed on just the soft tissue required to conduct the ulnar osteotomy. With an oscillating saw, the surgeon performs a transverse ulnar diaphyseal osteotomy. While maintaining all soft tissue attachments, the ulna is translocated to align with the radius and the third metacarpal and then internally fixed to the proximal fragment of the radius with a plate and screws. The forearm is in mid-prone posture during wrist arthrodesis. Full pronation and supination are evaluated before final fixation (Fig. 2). The limb was placed above the elbow slab for 6–8 weeks, followed by a detachable wrist splint until radiological evidence of union (Fig. 3). Graded postoperative physiotherapy (finger movements, hand ball therapy, forearm pronation/supination) programs were guided by the clinical and radiological findings. All the operations were performed at the university hospital of tertiary care within the time span of 2.5 years.

Clinical assessments regarding the functional status and complications were performed at regular intervals of 3–6 months. The grip strength was compared to the opposite hand by the dynamometer. The functional results were evaluated using the Musculoskeletal Tumor Society (MSTS) scoring system and Disability of Arm, Shoulder, and Hand (DASH) score[10–13]. The 1993 MSTS scoring system[14], completed by a member of the treating physician, was established to assess the functional result and quality of life following therapy for musculoskeletal tumours. This method was developed primarily to determine the function of a single limb. The MSTS scoring system for Upper Extremity is based on examining factors pertinent to the patient as a whole and those specific to the upper limb. It includes six categories: pain, function, emotional tolerance, hand positioning, manual dexterity, and lifting capacity. Each category was assigned a point value between 0 and 5, and the final score was a cumulative total with a maximum of 30 points. The DASH score is a self-administered questionnaire with 30 items linked to functional activities and symptoms in everyday activities (ADL). The patient is asked to score between 1 and 5 for each of the 30 things. Scores increase as impairment increases. The DASH has been widely studied regarding its reliability, repeatability, internal consistency, validity, and degree of clinical practice adoption[15–18]. It has been utilized for shoulder, hand, elbow, and wrist issues. Regardless of diagnosis, the DASH is recognized as an effective method for evaluating patients in general upper limb surgery. Statistics work was done with SPSS Statistics 22.0 (IBM, America). Paired *t*-tests were used to compare the MSTS and DASH scores separately before and after the operation. Statistical differences were considered significant at P less than 0.05.

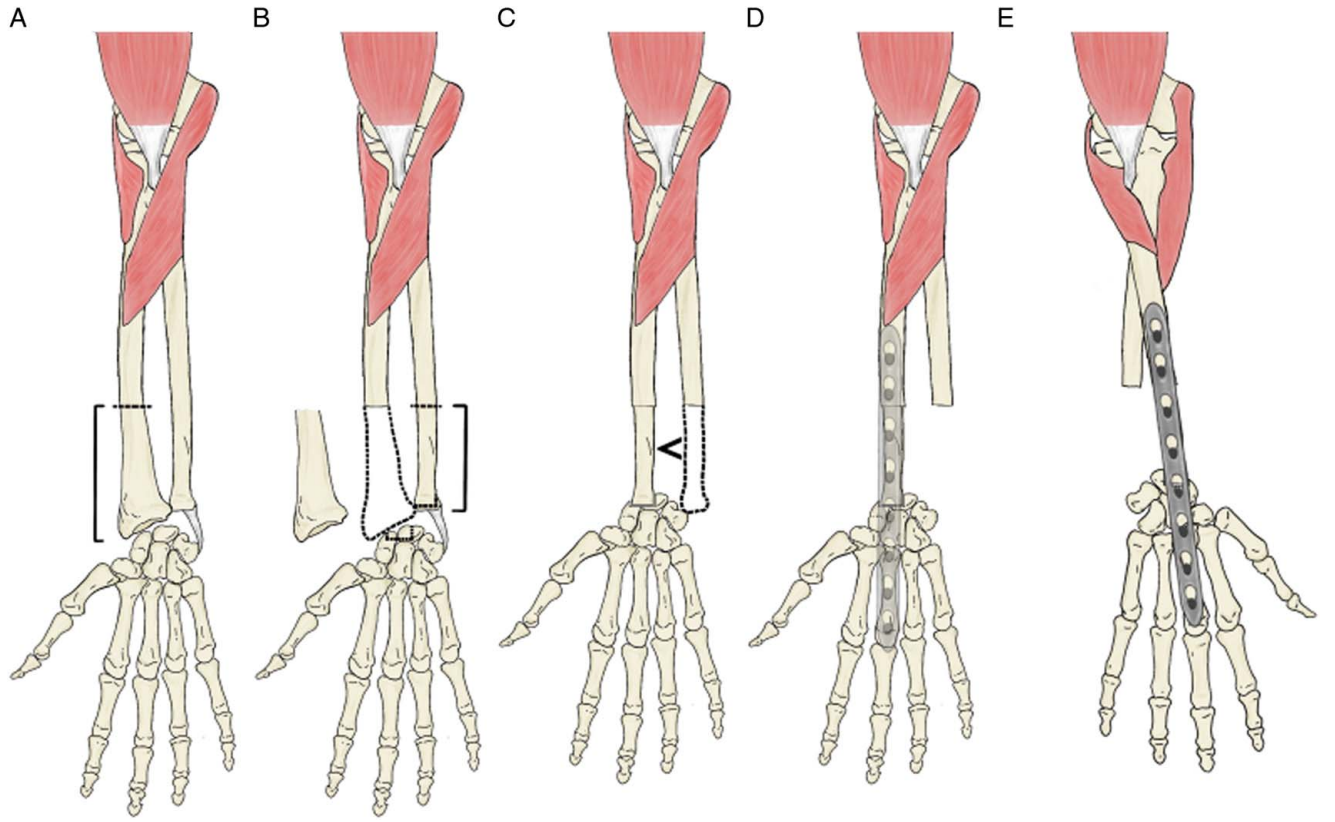

Figure 2. Schematic drawing of ulna translocation reconstruction. (A) En-bloc resection of the distal radius. (B) Osteotomy of the proximal and distal ipsilateral ulna. (C) Translocation of the osteotomized ulna onto the radius bone. (D) Wrist arthrodesis using plate and screws. (E) Illustration of supination and pronation movements of the forearm after internal fixation is performed.

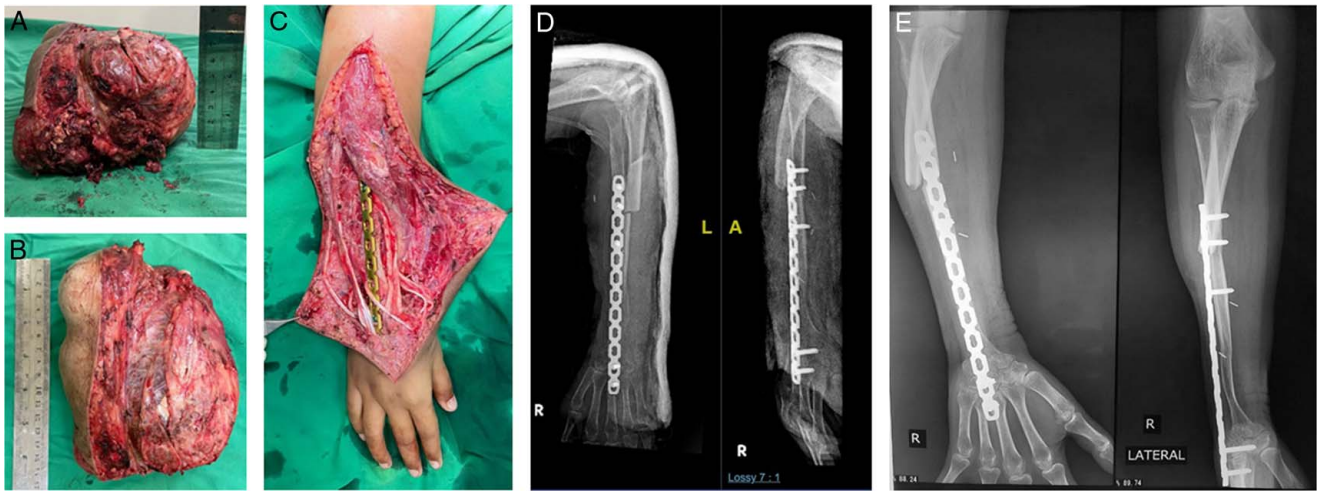

Figure 3. Excision of GCTB of distal radius followed by subsequent reconstruction with translocation of the ulna and wrist arthrodesis. (A, B) The tumour is excised along with the pronator quadratus muscle enveloping the tumour in the distal radius. (C) osteotomy was performed at the ipsilateral ulna and then translocated in alignment proximally with the radial stump, then distally with the scapholunate aligned with the 3rd metacarpal. Fixation is achieved with a plate and screws. (D) Early postoperative imaging after reconstruction (E) Postoperative imaging took six months after reconstruction. GCTB, giant cell tumour of the bone.

The study was reported according to the PROCESS 2020 criteria[19]. The study was registered in open access database (UIN: researchregistry8772).

Result

The mean age of four male and three female patients included in the study was 25.43 ± 8.40 years (with a range of 19–43 years old). All the patients were classified as stage 3 according to the Campanacci staging. The side affected was left in four cases and right in three cases. During this study, the mean follow-up period was 14.43 ± 8.08 months (with a range of 6–26 months), and the average length of tumour resection was 9.78 ± 2.88 cm. The average range of motion of the involved forearm was 82.66° of supination and 81.54° of pronation. They preserved an average of 95.93% of the contralateral forearm pronation and 97.24% of the contralateral forearm supination range of motion. Grip strength compared to the contralateral hand was found to be 34.7–75.2% (mean 55.38%). As shown in Table 1, the MSTS scores increased after the operation compared to the preoperative status. The average MSTS score was 11.71 ± 2.21 before and 25.14 ± 2.41 after the operation ($P < 0.05$). The average DASH

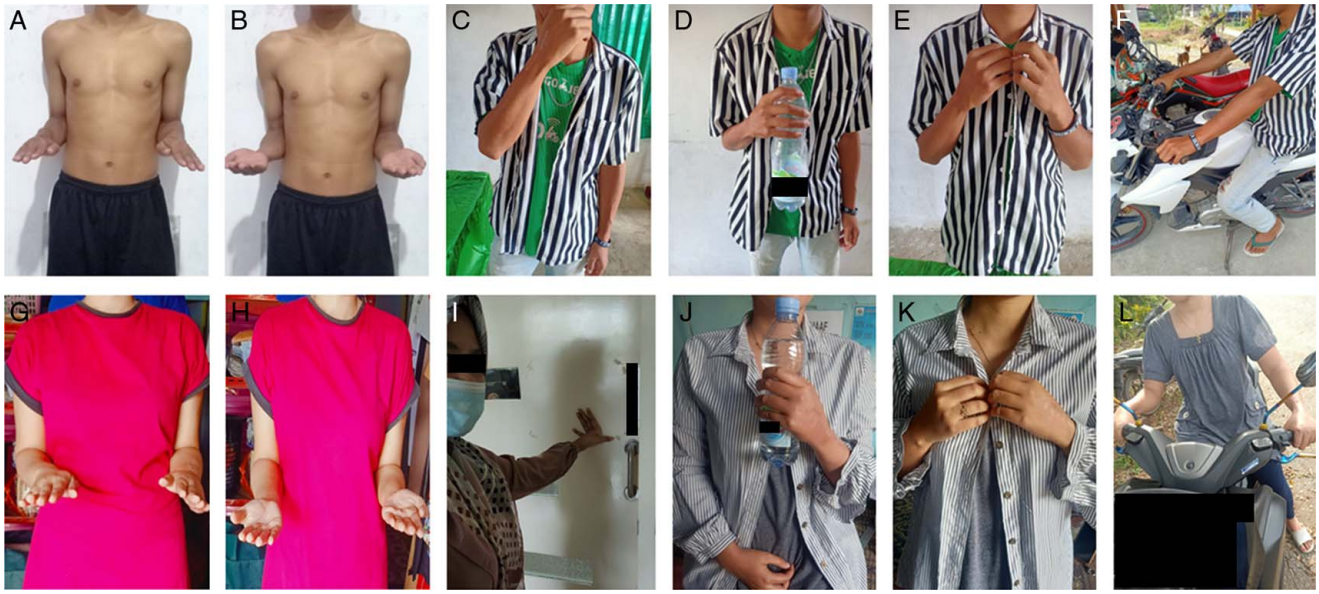

Figure 4. Representative postoperative clinical findings of 2 patients with 26 months and 14 months of follow-up showed excelent pronation, supination, and ability to perform daily activities. The first patient (26 months of follow-up). (A, B) Pronation and supination. (C) Eating. (D) Drinking. (E) Buttoning. (F) Riding motorcycle. Second Patient (14 months of follow-up). (G, H) Pronation and supination. (I) Exert force on a heavy door. (J) Drinking. (K) Buttoning. (L) Riding motorcycle.

score on admission was 40.14 ± 14.66, which decreased to 9.02 ± 4.23 after the operation ($P < 0.05$). Both scores revealed outstanding functional outcomes postoperatively (Table 1, Fig. 4). The tumour recurrence in one patient was found 18 months after surgery. There were no infections in all patients. However, one patient experienced issues from radioulnar synostosis (Fig. 5).

Discussion

Studies have shown that it is possible to remove the tumour while keeping wrist and hand function when treating Campanacci grade 3 GCTB of the distal radius[20]. However, intralesional excision through curettage is linked to a high recurrence rate[6]. Wide tumour removal is, therefore, necessary for Campanacci grade 3 GCTB[1,21]. When removing the tumour and repairing the bone defect in Campanacci grade 3 of the GCTB distal radius, keeping the limb's functionality as good as feasible is essential. Historically, various methods have been developed for managing bone defects after the wide excision of GCTB at the distal radius. These methods include prostheses, allografts, and both vascularized and non-vascularized autografts, with the option of either wrist arthrodesis or preserving wrist motion[1,7,22]. The choice of a reconstruction technique is also influenced by the surgeon's experience, the accessibility of medical equipment, the length of time needed to perform the procedure, any potential complications, and the patient's expectations.

Simple techniques such as wrist arthrodesis with translocation of the ulna can be performed with limited medical instruments and short operating time, resulting in a painless and stable forearm with preservation of pronation and supination in the forearm. Our study demonstrated that wide resection of the tumour preserved pronosupination movements in all our patients. Due to the ulna acting as a vascularized graft to fill the defect following resection, the length of the radius resection is not limited[23]. The surgeon might increase the length of the resected radius segment to ensure a margin free of tumour.

By transferring the carpus centring over the ulna after the tumour was removed, a different alternative to the reconstructive method—ulnar centralization—was reported by Murphy *et al*.[24] However, this procedure resulted in a loss of forearm rotations[4,24,25]. In contrast to ulnar centralization, ulnar translocation has the advantage of retaining some of the pronosupination movements of the forearm. Hence, Bhan *et al*.[23], in their study evaluating the functional outcome with a similar technique, reported that 80% of the patients had an excellent outcome. Our study had a comparable outstanding outcome, demonstrated by an elevated MSTS score, a lowered DASH score, and a statistically significant difference between these functional scores before and after surgery. The author searched for comparable studies and discovered that several studies from 1982 to 2017 showed

Figure 5. Patient with radioulnar synostosis complication 5 months after reconstruction. The synostosis was released. The postoperative functional outcome shows a satisfying result. (A) A 5-month follow-up X-ray showed a radioulnar synostosis. (B) Postoperative X-ray after the release of radioulnar synostosis. (C, D Pronation and supination. (E) Overhead lifting. (F) Opening a tight water bottle. (G) Back scratching. (H) Buttoning of shirt.

Table 1

Characteristics of patients with GCTB distal radius along with functional outcomes following translocation of ulna with ulnocarpal fusion

		Affected						MSTS Score		DASH Score		Forearm rotation (% of opposite site)		
No	Age (Years)/sex	Side	Dominant side (yes/no)	Primary/recurrent	Resection length (cm)	Follow-up (months)	Grip strength (% of the opposite side)	Pre	Post	Pre	Post	Pronation	Supination	Local complications
1	43/M	Left	No	Primary	10	6	—	10	23	32.40	7.40	78,00° (91,76)	82,00° (96,47)	None
2	20/M	Left	No	Primary	10.5	8	52.8	10	28	68.30	7.75	83,50° (98,24)	84,30° (99,18)	Radioulnar synostosis
3	21/F	Right	Yes	Primary	15	6	34.7	10	26	38.90	10.18	84,20° (99,06)	81,90° (96,35)	None
4	27/F	Left	No	Primary	11	14	59.8	13	27	28.30	3.33	83,70° (98,47)	84,30° (99,18)	None
5	21/F	Right	Yes	Primary	6	20	—	10	22	48.28	16.90	78,20° (92,00)	80,00° (94,12)	Recurence
6	19/M	Right	Yes	Primary	8	26	75.2	14	23	25.00	10.70	80,30° (94,47%)	83,80° (98,59%)	None
7	27/M	Left	No	Primary	8	21	54.4	15	27	39.80	6.89	82,90° (97,53)	82,30° (96,82)	None
Mean ± SD	25.43 ± 8.40		-	-	9.78 ± 2.88	14.43 ± 8.08	—	11.71 ± 2.21	25.14 ± 2.41	40.14 ± 14.66	9.02 ± 4.23	95.93 ± 3.14%	97.24 ± 1.85%	

DASH, Disability of Arm, Shoulder, and Hand; GCTB, giant cell tumour of the bone; MSTS, Musculoskeletal Tumor Society.

similar findings to those of our study (Table 2). From those studies, we can conclude that ulnar translocation is an alternative reconstruction method for Campanacci Grade 3 GCTB of distal radius after wide resection[2,4,26–28].

Ulnar translocation does not disrupt muscular attachments to the ulna, conserving its blood supply as in vascularized grafts, thus simplifying the operation by eliminating the need for the complex microvascular procedure. Preserving blood supply helps create a favourable biologic environment for healing, thus promoting union at the fusion site. During our surgical procedures, we tried to avoid excessive removal of soft tissue while preparing the ulna to prevent nonunion. We observed no nonunion-related problems in all patients during our recent follow-up[6,21,25].

In our study, we evaluated the grip strength of our participants using a handheld dynamometer. The results showed that in five patients, the remaining grip strength on the affected side ranged from 34.7 to 75.2% compared with the contralateral side. We showed from our study that the longer the follow-up time, the better the postoperative grip strength the patient will have. Another study conducted in 2018 by Vyas *et al.*[27] with 20 participants and a mean follow-up time of 3.9 years found that the average grip strength was reduced by 70% compared with the normal counterpart, consistent with our finding. Our subjects could still carry out their daily activities despite the diminished grip strength.

We found two local problems following the surgery during our study. A GCT recurrence in one patient was observed 18 months following the procedure. This local tumour recurrence is not considered as a consequence of the reconstruction strategy[7]. The incidence of local recurrence was 15%, consistent with descriptions of Campanacci grade 3 GCTB of the distal radius found in the literature[29]. Five months following the initial operation, radioulnar synostosis appeared in another patient. This patient experienced limited pronosupination movements but reported no pain at the follow-up visit. At the most recent follow-up, the patient demonstrated good functional improvement after releasing the radioulnar synostosis. To avoid radioulnar synostosis and maintain forearm pronation and supination movements, care was given to make sure that the periosteal sleeve had been completely separated around the ulna at the level of the proximal osteotomy before transposing the ulna[7].

This study has some limitations. Firstly, this is a retrospective study with a limited number of patients, especially those with Campanacci III classification, due to the rarity of GCT of the bone at the distal radius. Second, the evaluation of the MSTS and DASH score results was deemed to be subjective. Finally, the follow-up period was not equal for all individuals.

Conclusion

Wrist arthrodesis combined with ulnar translocation can be considered a simple and effective reconstruction method with preservation of function after wide resection of Campanacci grade 3 GCTB of the distal radius. It provides good functional rotation of the forearm with low complication rates. We still need to evaluate with a cohort study based upon prospective data with larger sample size.

Table 2

Cases reviewed in literature with wrist arthrodesis and ulnar translocation after en-bloc resection of GCTB of the distal radius.

Author	Sample size	Functional outcome	Complication	Mean follow-up duration
Seradge[9]	2	Useful and pain-free extremity with 85% forearm rotation	None	2 years
Lalla and Bhupathi[1]	1	The good functional result with near complete rotation of pronation and supination of the forearm	None	2 years
Bhan and Biyani[23]	6	Patients had excellent forearm rotation and an acceptable appearance. Grip strength is 50–75% compared to the contralateral hand.	Nonunion at radioulnar junction	3–5 years
Chalidis and Dimitrou[26]	1	Pain-free, 70° of supination and 60° of pronation, grip strength 80% compared with contralateral hand.	None	13 years
Puri et al.[7]	12	Excellent pronation and supination in 11 patients. The mean MSTS score was 26 (87%)	2 superficial skin necrosis 1 superficial wound infection 3 soft tissue recurrence 1 radioulnar synostosis 1 pulmonary metastasis	26 months
Mc Lean et al.[4]	3	The good functional outcome with average 80° pronation and 70° supination, mean TESS score was 86	None	30–51 months
Salunke et al.[2]	25	All patients had an excellent range of pronation and supination, a mean MSTS score of 24, and grip Strength was found to be good.	1 surgical site infection 1 nonunion 1 recurrence 2 implant failure	23 months
Vyas et al.[27]	20	Good function with 77.5° pronation and 80.25° supination. The mean grip strength is 71% of the normal side	1 recurrent 2 superficial infections	3.9 years
Agrawal A et al.[21]	1	The excellent functional outcome with 70° of forearm supination and 80° of forearm pronation, good functional finger grip, MSTS score of 28.	None	24 months
Srikanth et al.[28]	4	Average MSTS score was 27. Average VAS score was 1	None	26 months

GCTB, giant cell tumour of the bone; MSTS, Musculoskeletal Tumor Society; VAS, Visual Analog Scale; TESS, Toronto Extremity Salvage Score.

Ethical approval

Ethical approval no. UH2ZL2O767 from the Faculty of Medicine, Hasanuddin University, Indonesia.

Consent

The procedures and potential risks of the surgery were explained to the patient, who then provided signed informed consent.

Source of funding

None.

Author contribution

Conceptualization and design of the study: M.P.J., H.Y., M.A.A., J.A., M.A.U., T.S., M.R.S.; acquisition of data: M.P.J., A.E.S., H.Y., L.C.S., M.A.A., J.A., M.A.U., M.R.S.; performed the operation: M.P.J., M.R.S.; assist the operation: A.E.S., L.C.S., M. A.A.; analysis and interpretation of data: M.P.J., A.E.S., H.Y., M. A.A., J.A., M.A.U., T.S., M.R.S.; drafting the article or making critical revisions related to relevant intellectual content of the manuscript: M.P.J., A.E.S., H.Y., L.C.S., M.A.A., J.A., M.A.U., T.S., M.R.S.; supervision: M.P.J., H.Y., T.S., M.R.S.; validation: M.P.J., A.E.S., H.Y., L.C.S., M.A.A., J.A., M.A.U., T.S., M.R.S.; final approval of the version of the article to be published: M.P.J., A.E.S., H.Y., L.C.S., M.A.A., J.A., M.A.U., T.S., M.R.S. All authors have read and agreed to the published version of the manuscript.

Conflicts of interest disclosure

The authors declare that there is no conflict of interests regarding the publication of this paper.

Research registration unique identifying number (UIN)

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3. Hyperlink to your specific registration (must be publicly accessible and will be checked) : https://www.researchregistry.com/browse-the-registry#home/registrationdetails/641819c33bc07f0028000bdf/.

Guarantor

The guarantor in this study is M.P.J.

Provenance and peer review

Not commissioned externally peer-reviewed.

References

[1] Lalla RN, Bhupathi SC. Treatment of giant cell tumor of the distal radius by ulnar translocation. A case report and review of the literature. Orthopedics 1987;10:735–9.

[2] Salunke AA, Shah J, Warikoo V, *et al*. Giant cell tumor of distal radius treated with ulnar translocation and wrist arthrodesis. J Orthop Surg Hong Kong 2017;25:2309499016684972.
[3] Athanasian EA. Aneurysmal bone cyst and giant cell tumor of bone of the hand and distal radius. Hand Clin 2004;20:269–81.
[4] McLean JM, Clayer M, Stevenson AW, *et al*. A modified ulnar translocation reconstruction technique for Campanacci grade 3 giant cell tumors of the distal radius using a clover leaf plate. Tech Hand Up Extrem Surg 2014;18:135–42.
[5] Rtaimate M, Laffargue P, Farez E, *et al*. Reconstruction du radius par greffon fibulaire non vascularisé pour tumeur osseuse primitive (à propos de quatre cas. Chir Main 2001;20:272–9.
[6] Liu Y-P, Li K-H, Sun B-H. Which treatment is the best for giant cell tumors of the distal radius? A meta-analysis. Clin Orthop 2012;470:2886–94.
[7] Puri A, Gulia A, Agarwal MG, *et al*. Ulnar translocation after excision of a Campanacci grade-3 giant-cell tumour of the distal radius: an effective method of reconstruction. J Bone Joint Surg Br 2010;92:875–9.
[8] O'Donnell RJ, Springfield DS, Motwani HK, *et al*. Recurrence of giant-cell tumors of the long bones after curettage and packing with cement. J Bone Joint Surg Am 1994;76:1827–33.
[9] Seradge H. Distal ulnar translocation in the treatment of giant-cell tumors of the distal end of the radius. J Bone Joint Surg Am 1982;64:67–73.
[10] Germann G, Wind G, Harth A. Der DASH-Fragebogen - Ein neues Instrument zur Beurteilung von Behandlungsergebnissen an der oberen. Extremität Handchir Mikrochir Plast Chir 1999;31:149–52.
[11] Gummesson C, Atroshi I, Ekdahl C. The disabilities of the arm, shoulder and hand (DASH) outcome questionnaire: longitudinal construct validity and measuring self-rated health change after surgery. BMC Musculoskelet Disord 2003;4:11.
[12] Haldorsen B, Svege I, Roe Y, *et al*. Reliability and validity of the Norwegian version of the Disabilities of the Arm, Shoulder and Hand questionnaire in patients with shoulder impingement syndrome. BMC Musculoskelet Disord 2014;15:78.
[13] de Klerk S, Jerosch-Herold C, Buchanan H, *et al*. Structural and cross-cultural validity of the Afrikaans for the Western Cape Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire. J Patient-Rep Outcomes 2023;7:1.
[14] Enneking WF, Dunham W, Gebhardt MC, *et al*. A system for the functional evaluation of reconstructive procedures after surgical treatment of tumors of the musculoskeletal system. Clin Orthop 1993:241–6.
[15] Davis AM, Beaton DE, Hudak P, *et al*. Measuring disability of the upper extremity: a rationale supporting the use of a regional outcome measure. J Hand Ther Off J Am Soc Hand Ther 1999;12:269–74.
[16] Dowrick AS, Gabbe BJ, Williamson OD, *et al*. Outcome instruments for the assessment of the upper extremity following trauma: a review. Injury 2005;36:468–76.
[17] MacDermid JC, Richards RS, Donner A, *et al*. Responsiveness of the short form-36, disability of the arm, shoulder, and hand questionnaire, patient-rated wrist evaluation, and physical impairment measurements in evaluating recovery after a distal radius fracture. J Hand Surg 2000;25:330–40.
[18] SooHoo NF, McDonald AP, Seiler JG, *et al*. Evaluation of the construct validity of the DASH questionnaire by correlation to the SF-36. J Hand Surg 2002;27:537–41.
[19] Agha RA, Sohrabi C, Mathew G, *et al*. The PROCESS 2020 Guideline: Updating Consensus Preferred Reporting Of CasE Series in Surgery (PROCESS) Guidelines. Int J Surg 2020;84:231–5.
[20] Chobpenthai T, Thanindratarn P, Phorkhar T, *et al*. The reconstruction after en-bloc resection of giant cell tumors at the distal radius: a systematic review and meta-analysis of the ulnar transposition reconstruction technique. Surg Oncol 2020;34:147–53.
[21] Agrawal AC, Garg AK, Choudhary R, *et al*. Giant cell tumor of the distal radius: wide resection, ulna translocation with wrist arthrodesis. Cureus 2021;13:e15034.
[22] Baek JH, Chung DW, Alhassan T, *et al*. Wrist reconstruction using free vascularized fibular head graft following intralesional excision for campanacci grade 3 giant cell tumors involving the articular surface of the distal radius. J Hand Surg 2022;471231:e1–1231.e6.
[23] Bhan S, Biyani A. Ulnar translocation after excision of giant cell tumour of distal radius. J Hand Surg Edinb Scotl 1990;15:496–500.
[24] Murphy GRF, Logan MPO, Smith G, *et al*. Correction of "Wrist" deformity in radial dysplasia: a systematic review and meta-analysis. J Bone Joint Surg Am 2017;99:2120–6.
[25] Meena DK, Thalanki S, Sharma SB. Wrist fusion through centralisation of the ulna for recurrent giant cell tumour of the distal radius. J Orthop Surg Hong Kong 2016;24:84–7.
[26] Chalidis B, Dimitriou C. Modified ulnar translocation technique for the reconstruction of giant cell tumor of the distal radius. Orthopedics 2008;31:608.
[27] Vyas A, Patni P, Saini N, *et al*. Retrospective analysis of giant cell tumor lower end radius treated with en bloc excision and translocation of ulna. Indian J Orthop 2018;52:10–4.
[28] Srikanth E, Kancherla NR, Arvind B, *et al*. Campanacci grade III giant cell tumors of distal end radius treated with wide excision and reconstruction: a retrospective case series. Cureus 2022;14:e27818.
[29] Khan MT, Gray JM, Carter SR, *et al*. Management of the giant-cell tumours of the distal radius. Ann R Coll Surg Engl 2004;86:18–24.