The Results of Single Bone Forearm Procedure for Malignant Proximal Radius Tumors

Malign Proksimal Radius Tümörlerinde Single Bone Forearm Prosedürü Sonuçları

Abdullah Merter, Mustafa Onur KARACA, Kerem Başarır, Yusuf Yıldız

Ankara Üniversitesi Tıp Fakültesi Ortopedi Ve Travmatoloji Ana Bilim Dalı, Ankara

Dergiye Ulaşma Tarihi: Dergiye Kabul Tarihi: Doi: 10.5505/aot.2020.32032

ÖZET

GİRİŞ ve AMAÇ: Proksimal radius tümörlerinin rezeksiyonu sonrasında, birçok rekonstrüksiyon tekniği tanımlanmış olmasına rağmen, hangi tekniğin en uygun olduğu konusu hala tartışmalıdır. Bu çalışmanın amacı geniş yumuşak doku ve kas tutulumu olan olgularda single bone forearm tekniğinin sonuçlarının araştırılmasıdır.
YÖNTEM ve GEREÇLER: 2008-2014 yılları arasında 9 hastaya en bloc proksimal radius rezeksiyonu ve sonrasında single bone forearm procedürü uygulandı. Ortalama takip süresi 49.1 ay(46-52)dı. Hastalarda VAS(Visual Analog Scale), Quality of Life (SF-30) skoru, modified musculoskeletal tumor society (MSTS) skoru ve diğer üst ekstremitesiyle kıyaslanmak üzere eklem hareket açıklığı(ROM) ve kavrama güçleri karşılaştırıldı. Ayrıca kaynama zamanı, ek cerrahi operasyonlara ihityaç ve nüks açısından da değerlendirildi. **BULGULAR:** 6.aydaki ortalama eklem hareketleri açısından, 70°(60°-75°) el bileği ekstansiyonu, 90° (70°-95°) el bileği fleksiyonu, 25° (15°-35°) radial deviasyonu, 25º (15°-29°) ulnar deviasyonu ve 0º supinasyon ve pronasyon olarak ölçüldü. VAS ve SF-30 skorlarında iyileşme sağlanmış olup, ortalama modifiye MSTS skoru %72,77(63-82) olarak ölçüldü. Akciğer metastazından ötürü bir hasta öldü. Rekürrens gözlenmedi. Neoadjuvan radyoterapi almış 3 hasta pseudoartroz sebebiyle yeniden opere edildi.
TARTIŞMA ve SONUÇ: Single bone forearm tekniği, geniş yumuşak doku tutulumu olan proksimal radius tümörlerinin rezeksiyonu sonrasında rekonstrüksiyon tekniği olarak alternatif ve akılda tutulması gereken bir tekniktir.
Anahtar Kelimeler: Single-bone forearm procedure, Proximal radius kemik tümörleri, Proksimal radius rekonstrüksiyonu

ABSTRACT

INTRODUCTION: Despite several surgical techniques introduced for the treatment of malignant tumors of proximal radius, the most appropriate treatment remains to be undiscovered. The aim of the study is to analyze the results of patients who underwent proximal radius resection and reconstruction with the single bone forearm procedure in malignant tumors involving the proximal radius with large muscle and soft tissue.
METHODS: Between 2008 and 2014, 9 patients with malignant tumors involving the proximal radius were treated by en bloc resection and reconstruction with the single bone forearm procedure. Patients were followed for 49.1(46-52) months. VAS (Visual Analog Scale), Quality of Life (SF-30), modified musculoskeletal tumor society (MSTS) scoring system, range of motion (ROM) and grip strength compared to contralateral side were measured. Also, time of union, need for further operations and recurrence of the tumor were evaluated.
RESULTS: The mean ranges of the ROM of extremity at the follow up of sixth month was 70°(60°-75°), wrist extension, 90° (70°-95°) palmar flexion, 25° (15°-35°) radial deviation, 25º (15°-29°) ulnar deviation, 0º supination, and 0º pronation. VAS and SF-30 were improved dramatically. The mean modified MSTS score was 72.77(63-82)%. Death from lung metastasis occurred in one patient. Recurrence did not occur. Three patients who had been given neoadjuvant radiotherapy underwent pseudoarthrosis surgery.
DISCUSSION AND CONCLUSION: Single bone forearm technique after proximal radius resection is a good alternative procedure in proximal radius malignant tumors with advanced soft tissue involvement.
Keywords: Single-bone forearm procedure, Proximal radius bone tumours, surgical techniques for proximal radius resection

Adress for correspondence:
e-mail:
Available at www.actaoncologicaturcica.com

INTRODUCTION

Radius was only involved in 3.7 % (benign 3.4 %, malignant 0.3 %) in all musculoskeletal tumors (1,2). Ozturk et al also reported that 1.2% of bone metastases and 1.8% of all bone tumors were located in the radius (3). Primary bone tumors of the proximal radius are even rarer.

The proximal radius is a major stabilizer for resisting valgus, rotatory, and axial forces of the elbow. The proximal radioulnar articulation also plays an important role in the rotation. In addition, 60 % of the upper limb load is transferred through the radiocapitellar joint (4,5). Injury of the proximal radius may adversely affect the forearm function. Therefore, a new pathway to carry the load must be reconstructed, which is necessary after proximal radius resection.

Multiple techniques have been used to reconstruct the proximal radius due to tumoral lesions, including free vascularized fibular bone graft (6), bipolar type floating radial head prosthesis (7), and vascularized iliac crest graft (8). However, all of these techniques are suitable for proximal radius tumors moderate or mild destruction limited only to the bone or limited soft tissue involvement. If the malignant lesion in the proximal radius is advanced and has spread into the surrounding tissues (extensor, pronator and supinator muscles and posterior interosseous nerve involvement), a single bone forearm technique may be prefferedas a salvage, instead of rotation-preserving surgical interventions.

In this retrospective study, the long term results of (9) patients with malignant tumors involving the proximal radius with large soft tissue involvement who underwent proximal radius resection and reconstruction with the single bone forearm procedure were reported with at least 2 year follow up. A long follow-up study of this procedure for malignant lesions of proximal radius has not yet been described in literature.

MATERIAL METHOD

A total of 9 patients were collected from January 2008 to August 2016 for the study. All of them were initially assessed at a multidisciplinary oncoteam committee, evaluating the history, radiographs and the results of biopsies.

The inclusion criteria for this procedurewas malignant tumor with large soft tissue involvement in the proximal radius with a longitudinal axis of more than 10 cm and a axial diameter of more than 5 cm and no previous surgery.

The patients were examined clinically and radiologically by the same surgeon every 3 monthsuntil thesecond year. After the second year, a follow up of every 6 months were performed. The range of motion(ROM) of upper extremity, SF-30 score, Musculoskeletal Tumor Society score (MSTS) (9) and the Disabilities of the Arm, Shoulder, and Hand score (DASH) (10) were performed to evaluate the function of the forearm at last follow up.

The written informed consent was obtained from the patients, and the study was performed in accordance with the Declaration of Helsinki and approved by the ethics committee.

Surgical Technique

A wide resection was done at least one centimeter away from the distal border of the tumor using volar Henry approach. After dissection and resection of wide soft tissue component of the tumor, ulnar osteotomy was made at the same level and proximal ulna was fixed to the remnant radial shaft with a 3.5 mm

Adress for correspondence:
e-mail:
Available at www.actaoncologicaturcica.com

locking compression plate (LCP) while the forearm was in the neutral position. Distal radioulnar joint was fixed with a 3.5 mm non-locking cortical screw to prevent subluxation when it is necessary. Necessary tendon transfers for finger and wrist extension was performed using the tendons that not involved by the tumour at the proximally, if posterior interosseous nerve involvement existed. A long arm plaster cast was used to keep the elbow immobilized for about 3 weeks. The patient began functional training when the plaster cast was removed.

RESULTS

Of the 9 patients analyzed, there were 6 males and 3 females with 4 dominant sided involvement of the proximal radius. The mean age of patients included in the analysis was 38.1 years (25-45 years). The mean follow-up period was 49.1 (range, 46–52) months. Characteristics of the patients at the latest follow-up are presented in Table 1. There was no local recurrence. One patient who had been diagnosed to have pulmonary metastasis at the preoperative examination died of disease at 54 months. Radiological union was achieved in six patients after a mean of 8 (range, 6–10) weeks(Figure 1).The other three patients who had been given neoadjuvant radiotherapy had pseudoarthrosis six months after surgery. Two of them were performed iliac bone grafting and implant revision, the other one was performed vascularized fibula grafting (Figure 2) and radiological union was achievedin all cases at the final follow-up.

Figure 1: Patient No 4. 36 y F. Malign giant cell tumour(13,5*8*8 cm) with pulmonary metastases. **a)** Axial T1 MRI view **b)** Sagittal STIR MRI view **c)** Coronal T2 view **d)** Preoperative X-ray AP view **e)** Preoperative X-ray Lateral view **f)** Postoperative first week X-ray AP view **g)** Postoperative first week X-ray Lateral view **h)** Postoperative 8. week X-ray Lateral view

Figure 2: Patient No 1. 45 Y M. Ewing Sarcoma(12*7*7). **a)** Preoperative x-ray view. **b)** Preoperative sagittal and axial T1 MRI showed large soft tissue involment **c)** X-ray view demonstrated atrophic pseudoarthrosis 8 months after surgery **d)**Complete union was achieved with vascularized fibular bone graft after 6 months .

Adress for correspondence:
e-mail:
Available at www.actaoncologicaturcica.com

Table 1 The characteristics of patients

Patient No	Age	G	Dominant hand	Histopathological diagnosis	Metastases at the time of diagnosis	Neoadjuvant chemotherapy	Neoadjuvant radiotherapy	Tumour size(cm)	Resection length(cm)	PIN involment	Tendon transfer surgery	Surgery time (minute)
1	45	M	+	Ewing sarcoma	-	+	+	12*7*7	13	+	+	150
2	42	F	-	Sinovial sarcoma	-	+	+	10*5*5	11	+	+	160
3	25	M	-	Ewing sarcoma	-	+	+	11*6*5	12	+	+	150
4	36	F	-	Malign Giant Cell Tumour	Lung	-	-	13,5*8*8	14	-	-	160
5	42	F	-	Sinovial sarcoma	-	+	+	10*5*5	10	-	-	140
6	41	M	+	Ewing sarcoma	-	+	+	10*6*5	11	+	+	150
7	39	M	+	Sinovial sarcoma	-	+	+	12*5*5	13	+	+	140
8	44	M	-	Ewing sarcoma	Lung	+	+	11*4*4	12	+	+	140
9	29	M	+	Osteosarcoma	-	+	-	10*5*4	11	+	+	150

G Gender, *F* Female, *M* Male, *PIN* Posterior interrouseous nerve

Patient No	Length of hospital stay(day)	Adjuvant chemotherapy	Adjuvant radiotherapy	Follow Up time(months)	Pre/PO VAS score	Pre/PO SF-30 Score	PO MSTS Score	PO DASH Score	Recurrence	Pseudoarthrosis
1	7	+	+	48	6/2	42.5/70.2	63	34.2	-	-
2	5	+	+	52	7/2	44/75.2	75	33.5	-	+
3	6	+	+	46	5/1	43.2/72.1	82	35.0	-	+
4	6	+	-	48	6/3	39.1/68.4	66	30.1	-	-
5	6	+	+	50	8/2	38.2/69	75	29.4	-	-
6	5	+	+	48	8/2	41/72	71	18.4	-	-
7	5	+	+	50	7/3	40.5/66.4	78	10.5	-	+
8	5	+	+	52	8/1	41.3/68.4	76	12.6	-	-
9	7	+	-	48	7/1	41.5/69	69	30.4	-	-

Pre/PO Preoperative/ Postoperative 2nd year, *VAS* Visual Analog Scale, *SF-30* Short Form 30 (The quality of life scoring system), *MSTS* Musculoskeletal Tumor Society, *DASH* Disabilities of the Arm, Shoulder, and Hand

The mean active range of motion in the wrist at the sixth month follow up was 70° dorsiflexion, 90° palmar flexion, 25° radial deviations, 25º ulnar deviations and in the forearm, 0º supination, and 0º pronation. Compared with the contralateral wrists, the operated wrists regained 80% of the function except for the loss of pronation and supination, with satisfactory grip strength, and normal finger and thumb movements and hand sensation. The mean 2nd year Visual Analog Scale(VAS) score was 1.88(range, 1-3), SF 30 score was was 70.07(range, 66,4-75.2), MSTS score was 72.77 (range, 63-82), DASH score was 26.01 (range, 10.5-35.0) (Table 2).

DISCUSSION

The treatment of malignant and aggressive forearm tumors is complex and challenging for the surgeon. The primary goal is to achieve complete resection of the tumor without increasing the risk of local recurrence and the secondary goal is to preserve or reconstruct hand and upper limb function as possible. Nowadays, with the advances of chemotherapy, radiotherapy and surgical techniques, limb-sparing procedures are the preferred options in the treatment of musculoskeletal tumors.

After intra-articular resection of the proximal radius,reconstruction is required to avoid from instability of the elbow and secondary problems at the wris (11). It can be reconstructed with various techniques, including vascularized/non-vascularized fibular grafts (6), osteoarticular allografts (12), allograft-prosthesis composites (13), endoprosthesis (14) and single-bone forearm reconstruction (15–17).

Biologic reconstruction using size-matched osteoarticular allograft is not straightforward and has been reported to produce unsatisfactory results (12). Vascularized fibular grafts appear to be effective at restoring bone stock, but reports of successful humeroradial joint reconstruction are scarce. It has also been pointed out in literature that vascularized fibular grafts functionally

Adress for correspondence:
e-mail:
Available at www.actaoncologicaturcica.com

preserve the desired forearm rotation movements after reconstruction of the tendon insersions attached to the radius and interosseous membrane with tumor resection (18). On the other hand, allograft prosthesis composites have been reported to produce excellent results for up to 4 years (13).

In our 9 cases, we had to have at least 10*5 cm in size resection as mentioned before; a single bone forearm technique was performed because all of the forearm rotation group muscles (except for the pronator quadratus muscle) and most of the interosseous membrane were excised and forearm rotation could not be achieved because of the advanced soft tissue involvement in these patients. This technique has advantageous because of the shorter duration of surgery compared to vascular fibular technique, no need for microsurgical experience, the short hospitalization period and the need for the patient to begin adjuvant treatment soon. It is known that long segment allograft reconstructions in the bones that do not carry incur in a longer period in terms of the union time (19). In the reconstructed endoprosthesis after resection, single bone forearm technique makes more sense because prosthesis survival is low and probability of infection is high. Also clinically, when the MSTS and DASH scores are examined together, we can say that the results of the single bone forearm technique are acceptable.

A review of literature revealed that no series had been performed with the number of patients as in this study and the follow-up times were not as long. Pseudoarthrosis developed 33% in our series. However, we view this rate as high due to the neoadjuvant and adjuvant radiotherapy. After the completion of adjuvant therapies, pseudoarthrosis surgery with iliac wing grafting and vascularized fibular graft was performed in these three patients.

The disadvantage of this technique over other techniques is that the forearm rotation can not be maintained. The point that we want to emphasize is that the rotation tried to be provided by other techniques such as vascularized fibular graft or endoprosthesis reconstruction is below the expectation of the patient in case of wide resection of the pronator-supinator muscle groups. Therefore, it is necessary to keep in mind the single bone forearm technique after resection as a very good alternative procedure in huge proximal radius malign tumors.

The low incidence of malignant tumors in radius bone is one of the limitations of this study. Secondly, a prospective study to compare this procedure with other techniques will show more reliable results.

Conclusion

Proximal radius tumors are very rare and reconstruction after resection is the key point in terms of quality of life. This procedure is an acceptable alternative methodin contrast to rotation preserving techniques in terms of better clinical results, shorter operation time and hospitalization for large proximal radius malign tumors.

On behalf of all authors, the corresponding author states that there is no conflict of interest.

Acknowledgments: The authors declared that this study has received no financial support.

REFERENCES

1. Bergovec M, Kubat O, Smerdelj M, Seiwerth S, Bonevski A, Orlic D. Epidemiology of musculoskeletal tumors in a national referral orthopedic department. A study of 3482 cases. Cancer Epidemiol. 2015;39(3):298-302. doi:10.1016/j.canep.2015.01.015
2. Picci P. Epidemiology. In: Atlas of Musculoskeletal Tumors and Tumorlike Lesions. Cham: Springer International Publishing; 2014:3-8. doi:10.1007/978-3-319-01748-8_1
3. Öztürk R, Arıkan ŞM, Bulut EK, Kekeç AF, Çelebi F, Güngör BŞ. Distribution and evaluation of bone and soft tissue tumors operated in a tertiary care center. Acta Orthop Traumatol Turc. 2019;53(3):189-194. doi:10.1016/j.aott.2019.03.008
4. Shepard MF, Markolf KL, Dunbar AM. Effects of radial head excision and distal radial shortening on load-sharing in cadaver forearms. J Bone Joint Surg Am. 2001;83-A(1):92-100.

Adress for correspondence:
e-mail:
Available at www.actaoncologicaturcica.com

5. Li SL, Lu Y, Wang MY. Is cross-screw fixation superior to plate for radial neck fractures? Bone Joint J. 2015;97-B(6):830-835. doi:10.1302/0301-620X.97B6.34868
6. Nonnenmacher J, Bahm J, Laforest P, Kempf I. Aneurysmal cyst of the proximal radius: resection and free vascularized fibular bone graft. Microsurgery. 1993;14(4):280-284.
7. Sakayama K, Sugawara Y, Kidani T, Miyawaki J, Yamamoto H. Bipolar-type floating radial head prosthesis for the treatment of giant cell tumor of the proximal radius: A case report. J Shoulder Elb Surg. 2006;15(5):9-12. doi:10.1016/j.jse.2005.06.001
8. Leung PC, Hung LK. Bone reconstruction after giant-cell tumor resection at the proximal end of the humerus with vascularized iliac crest graft. A report of three cases. Clin Orthop Relat Res. 1989;(247):101-105.
9. Enneking WF, Dunham W, Gebhardt MC, Malawar M, Pritchard DJ. A system for the functional evaluation of reconstructive procedures after surgical treatment of tumors of the musculoskeletal system. Clin Orthop Relat Res. 1993;(286):241-246.
10. Hudak PL, Amadio PC, Bombardier C. Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand). Am J Ind Med. 1996;29(6):602-608. http://0.133.224.88.
11. Li Y-A, Chang M-C, Chen T-S. Extreme comminuted fracture of the radial head fixed with multiple Kirschner wires: case report. J Trauma. 2009;67(4):E124-8. doi:10.1097/TA.0b013e318047e03e
12. Karlstad R, Morrey BF, Cooney WP. Failure of fresh-frozen radial head allografts in the treatment of Essex-Lopresti injury. A report of four cases. J Bone Joint Surg Am. 2005;87(8):1828-1833. doi:10.2106/JBJS.D.02351
13. Crawford EA, Brooks JSJ, Ogilvie CM. Osteosarcoma of the proximal part of the radius in Mazabraud syndrome. A case report. J Bone Joint Surg Am. 2009;91(4):955-960. doi:10.2106/JBJS.H.00212
14. Sakayama K, Sugawara Y, Kidani T, Miyawaki J, Yamamoto H. Bipolar-type floating radial head prosthesis for the treatment of giant cell tumor of the proximal radius: A case report. J Shoulder Elb Surg. 2006;15(5):e9-e12. doi:10.1016/j.jse.2005.06.001
15. Castle ME. One-bone forearm. J Bone Joint Surg Am. 1974;56(6):1223-1227.
16. Haddad RJ, Drez D. Salvage procedures for defects in the forearm bones. Clin Orthop Relat Res. 1974;(104):183-190.
17. Murray RA. The one-bone forearm: a reconstructive procedure. J Bone Joint Surg Am. 1955;37-A(2):366-370.
18. Sato R, Hamada Y, Hibino N, et al. Restoration of the Active Forearm Rotation Using Vascularized Free Fibular Graft and Radial Head Arthroplasty for a Wide Defect of the Proximal Radius. J Hand Surg (Asian-Pacific Vol. 2017;22(04):531-534. doi:10.1142/S0218810417720406
19. Saini R, Bali K, Bachhal V, Mootha AK, Dhillon MS, Gill SS. En bloc excision and autogenous fibular reconstruction for aggressive giant cell tumor of distal radius : a report of 12 cases and review of literature. J Orthop Surg Res. 2011;6(1):14. doi:10.1186/1749-799X-6-14

Adress for correspondence:
e-mail:
Available at www.actaoncologicaturcica.com