Reconstruction with a Custom made Prosthetic Wrist Arthrodesis after Bone Tumor Resections of the Distal Radius. Single Centre Experience*

Reconstrução com implante metálico personalizado de artrodese após ressecções de tumor ósseo do rádio distal. Experiência em um único centro

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Abstract

Objective The present study aimed at analyzing the clinical, radiological and functional results of the reconstruction of the distal radius after tumor resection with a custom-made metal arthrodesis implant and compare them with other types of distal radius reconstruction, as presented in the literature.
To our best knowledge, this is the first article describing this particular type of implant and patient functionality.

Methods Functional outcomes of reconstruction of the distal radius were assessed in a series of 4 patients. Three of the patients having had resection of giant cell tumors (GCTs), one patient having had resection of osteosarcoma.

Results There were no major implant-related complications like infection, nonunion or loosening. Two patients had to undergo further surgery for protruding metalwork. Overall function was good according to the Musculoskeletal Tumor Society MSTS and Disabilities of the Arm, Shoulder, and Hand (DASH) scores.

Conclusion The present study shows that custom-made metal arthrodesis implant benefits from the fact that it can be used as a salvage option when other treatments have failed, or it can be used as a primary option in cases in which there is limited bone stock after distal radius tumor resection.

Keywords
- sarcoma
- giant cell tumors
- distal radius
- wrist
- arthrodesis
- prosthesis

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Resumo

Objetivo O presente estudo teve como objetivo analisar os resultados clínicos, radiológicos e funcionais da reconstrução do rádio distal após a ressecção do tumor com implante metálico personalizado de artrodese e compará-los com outros tipos de reconstrução do rádio distal, conforme apresentado na literatura.

Pelo que conhecemos, este é o primeiro artigo descrevendo esse tipo particular de implante e funcionalidade no paciente.

Métodos Os desfechos funcionais de reconstrução do rádio distal foram avaliados em uma série de 4 pacientes. Três dos pacientes tiveram ressecção de tumores de células gigantes (TCGs), sendo um paciente com ressecção de osteossarcoma.

Resultados Não houve complicações relacionadas ao implante, como infecção, não sindicalidade ou afrouxamento. Dois pacientes tiveram que passar por uma nova cirurgia para a protusão da prótese metálica. A função geral foi boa de acordo com as pontuações da Musculoskeletal Tumor Society (MSTS) e Disabilities of the Arm, Shoulder, and Hand (DASH).

Conclusão O estudo mostra que o implante metálico personalizado de artrodese se beneficia do fato de que pode ser usado como opção de salvamento quando outros tratamentos falharam, ou pode ser usado como opção primária nos casos em que há estoque ósseo limitado após a ressecção do tumor do rádio distal.

Palavras-chave

- sarcoma
- tumores de células gigantes
- rádio distal
- punho
- artrodese
- prótese

Introduction

Reconstruction of the distal radius after a segmental resection for a bone tumor is often challenging. En-bloc resections are usually indicated for primary malignant bone tumors, and, occasionally, for advanced or recurrent benign bone tumors. The difficulty in reconstructing the distal radius is due to the complex anatomy of the wrist joint, the vicinity to important neurovascular structures, and the scarce local soft tissue coverage. As these patients are often young and active, a functional, stable, and durable reconstruction is required.

Many techniques have been applied to reconstruct the distal radius after tumor resection. Either wrist arthrodesis or joint reconstruction can be achieved using massive allografts, vascularized or nonvascularized autografts, ulnar transposition, and endoprosthetic implants. Most of the reports on distal radius reconstruction after tumor resection are single case studies or small series, due to the rarity of this indication.[1]

The authors of the present study describe a single institution experience in reconstruction of the distal radius after tumor resection with a custom-made metal arthrodesis implant. The aim of the present study was to analyze the clinical, radiological and functional results and compare them with other types of distal radius reconstruction, as presented in the literature.

Materials and Methods

A retrospective review was performed of 4 consecutive distal radius reconstructions with a custom-made metal arthrodesis implant. All operations were performed at the authors' institution in the period between 2009 and 2013. Clinical data were obtained from the notes, plain radiographs were evaluated, and the patients were contacted personally for the functional assessment. Data was collected regarding patients (age, gender, hand dominance), tumor characteristics (diagnosis, stage, margins), surgery (antibiotic prophylaxis, surgical approach, length of resection, soft tissue reconstruction), oncologic outcome and function. Functional results were analyzed according to the Musculoskeletal Tumor Society (MSTS) and the Disabilities of the Arm, Shoulder, and Hand (DASH) scoring systems. The radiographic evaluation included implant position and fixation, joint alignment, and degenerative changes in the nearby joints.

Prosthesis

The implant used for reconstruction of the distal radius was in all cases a CAD-CAM custom-made titanium endoprosthesis (Stanmore Implants Worldwide, Elstree, UK). The implant design was based on preoperative measurement films and 3-D CT reconstructions. All implants had a smooth stem for cement fixation in the residual radius, two bridging plates for screw fixation on the metacarpal bones, and a hydroxyapatite collar at the proximal and distal end to improve osseointegration and long-term fixation.

Surgery

Surgery was performed after standard antibiotic prophylaxis according to the institutional protocol, (1.5g of Cefuroxime at induction, followed by 750mg postoperative doses every 8 hours to complete 24h). Surgical access was obtained through a dorsal approach in all cases with longer incision allowing for metacarpal fixation of bridging plates.

The resection level of the distal radius was based on preoperative measurement films and scans. Custom made metal endoprosthesis was used for reconstruction, creating a fusion of the wrist joint. Proximal fixation at the residual radial shaft was obtained with polymethylmethacrylate

(PMMA) cement. Distally, the articular cartilage was removed from the scaphoid and lunate bones, to improve bone to implant contact at the first carpal row. Then the implant was fixed with screws and two bridging plates on the metacarpal bones. Positioning and design of bridging plates was done on an individual basis, taking into consideration soft tissue contracture after previous surgery, preoperative imaging studies and the anatomy of the patient. Centralization of the wrist was paramount for the postoperative functionality, hence the positioning of the bridging plates at different metacarpals. The operated limb was then immobilized in an above-elbow cast for 4 weeks, followed by a wrist splint for another 4 weeks.

Results

Patient Characteristics

There were two males and two females, with an average age of 42.5 years old (range 22 to 55 years old). All four cases were discussed at a sarcoma multidisciplinary team meeting in which available imaging and biopsy results were analyzed, and a treatment path was established.

Case 1

A 42-year-old right-hand-dominant female patient had previously undergone a right distal radius resection and reconstruction with a nonvascularized fibular graft for a primary giant cell tumor (GCT) of bone, 12 months prior. She then presented with extensive recurrent disease for which she underwent excision. This included en bloc resection of the fibular graft. The wrist was reconstructed with a custom-made endoprosthetic wrist arthrodesis, and the patient received 56 Gy of postoperative radiotherapy to prevent further local recurrence (►**Fig. 1**).

Case 2

A 22-year-old right-hand-dominant female patient presented with a localized high-grade osteoblastic osteosarcoma of the left distal radius, with a large soft tissue extension. She underwent neoadjuvant chemotherapy according to standard oncologic treatment protocols (EURAMOS-1). Resection of the distal radius was associated with en-bloc resection of the distal ulna to obtain wide surgical resection margins (►**Fig. 2**).

Case 3

A 54-year-old right-hand-dominant male patient presented with a primary GCT of bone in the left distal radius, for which he underwent resection and prosthetic reconstruction with a custom-made arthrodesis. No adjuvant treatments were applied in this case (►**Fig. 3**).

Case 4

A 50-year-old right-hand-dominant male patient had undergone a left distal radius resection and reconstruction with a nonvascularized fibular autograft for a primary GCT of bone. After 6 months, the fibular graft got infected, and the patient underwent a first stage revision with removal of the graft and implantation of an antibiotic-loaded cement spacer. After

Fig. 1 (**a**) Showing nonvascularized fibular graft . Due to local recurrence, the fibula graft was later excised and a custom-made wrist arthrodesis was implanted (**b**).

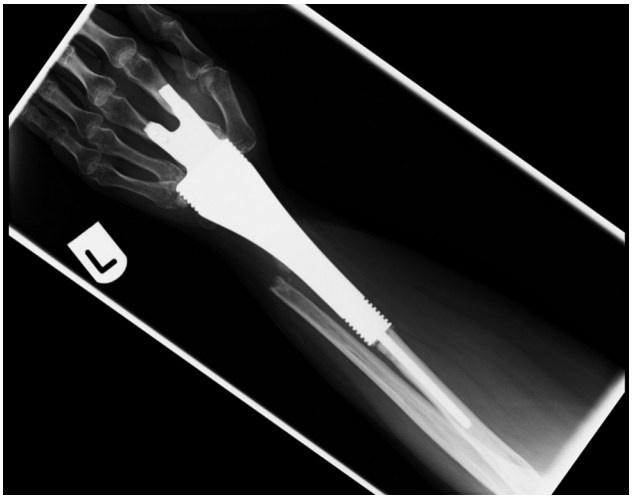

Fig. 2 Follow-up x-ray of the custom made wrist arthrodesis implant showing trimmed metacarpal bridging plates.

6 weeks of intravenous antibiotic treatment, all infection parameters returned to normal, and the patient underwent a second stage revision with a custom-made distal radius prosthetic arthrodesis (►**Fig. 4**).

Outcome

The average follow-up after arthrodesis with a custom made endoprosthetic implant was 50 months (range 22 to 70 months). No relapses were reported during the follow-up period. There were no perioperative complications. The wounds healed well in all cases and there were no signs of infection. All implants fused completely with the first carpal row, all wrists showed good alignment, and there were no radiological signs of stem loosening at the last follow-up. No patient complained of implant-related pain. However, in two cases, screws backed out from the bridging plates at the

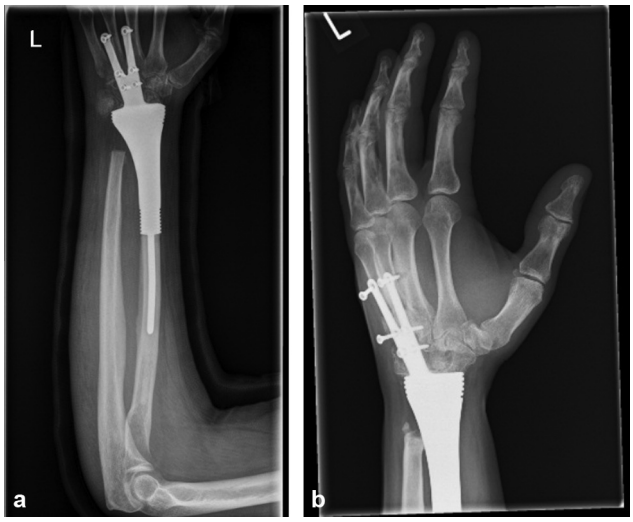

Fig. 3 (**a**) Postoperative x-ray of the custom-made wrist arthrodesis implant. (**b**) Follow-up x-ray showing protruding screws.

Fig. 4 Postoperative x-ray of the custom-made wrist arthrodesis implant.

level of the metacarpal bones, causing skin problems at the dorsal side of the hand. Both these patients underwent removal of the screws in a day case procedure without sacrificing implant functionality or disruption of the arthrodesis between implant and carpal bones. In one of these cases, a protruding plate was also partially removed at the same time. The functional results of the four cases, according to the MSTS and DASH scores, are presented in ►**Table 1**.

Discussion

In the present study, we have assessed the functional outcomes of reconstruction of the distal radius in four patients using a custom made prosthesis, three of the patients having had resection of GCTs, one patient having had resection of osteosarcoma. Giant cell tumor of bone is a benign, locally aggressive bone tumor. The natural history of GCT is progressive bone destruction leading to joint deformity and disability. The distal radius is one of the most common locations of GCT, after the distal femur, the proximal tibia and the proximal femur.[2] Osteosarcoma is the most common primary malignant bone tumor, but $< 1\%$ arise in the distal radius.[3,4]

Grade II and III Campanacci GCTs, osteosarcomas and other tumors causing thinning or penetration of the cortex are particularly challenging to treat.

Resection of the distal radius is a rare surgical indication. It is considered to be the treatment of choice for aggressive bone tumors with large bony destruction and advanced presentation. Wide excision in such cases creates a defect at the distal end of the radius.

Numerous procedures aiming at reconstruction of the segmental bony defect and functionality of the upper limb are described in the literature. These include: vascularized and nonvascularized fibular autografts, massive segmental allografts, ulnar transposition, and custom made megaprosthesis of the wrist joint.[5–8] The limited literature on distal radius reconstruction provides no consensus regarding the best surgical reconstruction techniques. The choice of the reconstruction technique is generally based on tumor extension and patient characteristics (age, functional demand), but also on the availability of reconstructive resources. Massive allografts require a bone bank organization. The method of choice of reconstruction has generally tended to be using fibular grafts, either vascularized or nonvascularized. The advantages of fibular grafts include their anatomic similarity to the distal radius and, therefore, their potential ability to allow for preservation of motion at the wrist joint. Although studies have shown promising outcomes, vascularized fibular grafts require microsurgical expertise. One of the largest series of vascularized fibular graft reconstructions after resection of tumor in limb salvage procedures documented a sizeable risk of complications, including revision rates or need for additional surgery at 35%[9] Studies have also shown limited wrist range of movement and accelerated degenerative changes at the fibular-carpal joint in some series.[10–12] Osteoarticular allografts represent an attractive option with studies showing good outcomes. Custom-made 3D printed implants still remain a relatively expensive solution. The reconstruction type can either maintain joint movement or create a stable fusion of the wrist joint. Wrist arthrodesis can be subclassified in total arthrodesis (bridging the forearm to the

Table 1 The functional results of the four cases, according to the MSTS and DASH scores

NR	SEX	AGE (yearsold)	DIAGNOSIS	FOLLOW-UP (months)	SIDE	Dominance	MSTS (%)	DASH
1	F	42	GCT	70	RIGHT	RIGHT	57	63
2	F	22	OS	54	LEFT	RIGHT	57	37
3	M	54	GCT	56	LEFT	RIGHT	77	46
4	M	50	GCT	22	LEFT	RIGHT	73	20

Abbreviations: DASH, Disabilities of the Arm, Shoulder, and Hand; F, female; GCT, giant cell tumor; M, male; MSTS, Musculoskeletal Tumor Society; OS, osteosarcoma.

metacarpal bones) or a partial arthrodesis (fixing the distal radius to the first carpal row). Total wrist fusion has been regarded as the most predictable treatment concept, with the belief that it results in only limited functional disability.[13] Although the functional outcome is acceptable for most patients, some adaptation is necessary, because certain activities such as personal care and manipulating the hand in tight spaces are difficult.[14] It is not clear to which extent some motion of the wrist is useful or necessary. In most impairment tables, there is a linear relationship between motion of the wrist and impairment.[15]

Due to the rarity of the surgical indication, most reports that describe reconstructions of the distal radius after bone tumor resection include a very limited number of cases. Besides this, there is lack of information available on the functional outcome of these reconstructions.

Overall, there were no major implant-related complications like infection, nonunion or loosening. Two patients had to undergo further surgery for protruding metalwork, but this was easily removed in a day surgery setting.

Function was good according to the MSTS and DASH scores, and all patients returned to normal daily activity without major impairments.[16]

Conclusion

The majority of wrist fusion options presented in the literature following tumor resection involve biological fusions, whereas our fusions have been done using an anatomical prosthesis.

Our implants, along with having a bridging component for the missing/resected diaphysis, fuses the radius to the carpus. The carpometacarpal arthrodesis component of our prosthesis increases stability and prevents loosening of the components. This type of prosthesis benefits from the fact that it can be used as a salvage option when other treatments have failed, or it can be used as a primary option in cases in which there is limited bone stock after distal radius tumor resection. This type of custom-made reconstruction appears to be a promising solution in difficult cases; however, further studies with larger study groups and longer follow-up are required.

Conflict of Interests

The authors have no conflict of interests to declare.

The present study was performed in compliance with the World Medical Association Declaration of Helsinki on Ethical Principles for Medical Research Involving Human Subjects, and was reviewed by the Royal National Orthopaedic Hospital Institutional Review Board

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