JSES Reviews, Reports, and Techniques 4 (2024) 131–135

Contents lists available at ScienceDirect

JSES Reviews, Reports, and Techniques

journal homepage: www.jsesreviewsreportstech.org

Revision total elbow arthroplasty for humeral loosening with large bone defect using femoral allograft and impaction bone grafting: a case report

Shiro Kajiyama, MD, PhD[a,*], Ritsu Tsujimoto, MD, PhD[a], Kenji Taguchi, MD, PhD[a], Tatsunari Aoki, MD[a], Kiyoshi Sada, MD, PhD[b], Ko Chiba, MD, PhD[c], Iku Tomonaga, MD[a], Makoto Osaki, MD, PhD[c]

[a]Department of Orthopaedic Surgery, Nagasaki University Hospital, Nagasaki, Japan
[b]Department of Orthopaedic Surgery, Jikei Hospital, Nagasaki, Japan
[c]Department of Orthopaedic Surgery, Graduate School of Biomedical Sciences, Nagasaki University, Nagasaki, Japan

ARTICLE INFO

Keywords:
Total elbow arthroplasty
Loosening
Revision surgery
Large bone defect
Allograft
Allograft-prosthesis composite
Impaction bone grafting
Locking plate

Total elbow arthroplasty (TEA) is mainly performed as a surgical treatment for elbow joint destruction due to rheumatoid arthritis or trauma such as comminuted intra-articular fracture. While good clinical results have been reported, various complications remain a concern during long-term follow-up.[2] One such complication is loosening of implants, particularly for cases involving huge bone defects. Management of defects according to the condition of the case is important. So far, reports have described reconstructions using autologous bone graft, allograft, and implants made for tumor cases.[3,5,7] We report the case of a woman who underwent revision TEA using femoral allograft and a locking plate for humeral-side loosening with a significant bone defect, in a long-term follow-up after tumor resection. Verbal and written consent was obtained from the patient.

Case report

The patient was a 59-year-old woman. She had undergone resection of a tumor in the distal humerus 35 years earlier at her previous doctor and underwent TEA 1 year after initial surgery. Since then, revision surgery had been performed twice at the previous doctor and three times at our hospital for loosening of the humeral- and ulnar-side components, every several years to a decade. In follow up after surgery 5 years ago, loosening on the humeral side gradually progressed and ADL impairment associated with pain appeared. No clinical or laboratory findings suggestive of infection were found (WBC 4800 $\times$ 10^3/μl, CRP 0.04 mg/dL). To compensate for the large bone defect, we decided to perform surgery with bone allograft material provided by the Kitasato University Hospital Bone Bank (KUBB). KUBB preserves the long bones of the lower extremities and femoral heads as allografts.[9] For this case, we planned reconstruction of a distal humeral bone defect and TEA revision, using a narrow allogeneic femoral diaphysis.

Preoperative X-ray showed re-loosening of the humeral stem 5 years after the previous operation, and perforation of the cortical bone at the tip of the stem (Fig. 1, *A* and *B*). No loosening was observed on the ulnar side. Preoperative computed tomography showed a distal humeral defect, stem loosening, thinning of the anterolateral cortex, and perforation (Fig. 2, *A* and *B*).

Operative procedure

Surgery was performed under general anesthesia in the supine position with a posterior approach and an additional anterior approach on the proximal side of the upper arm. The triceps muscle

Institutional review board approval was not required for this case report.

*Corresponding author: Shiro Kajiyama, MD, PhD, Department of Orthopaedic Surgery, Nagasaki University Hospital, 1-7-1 Sakamoto, Nagasaki, Nagasaki 852 8501, Japan.

E-mail address: kazico@nagasaki-u.ac.jp (S. Kajiyama).

https://doi.org/10.1016/j.xrrt.2023.10.006

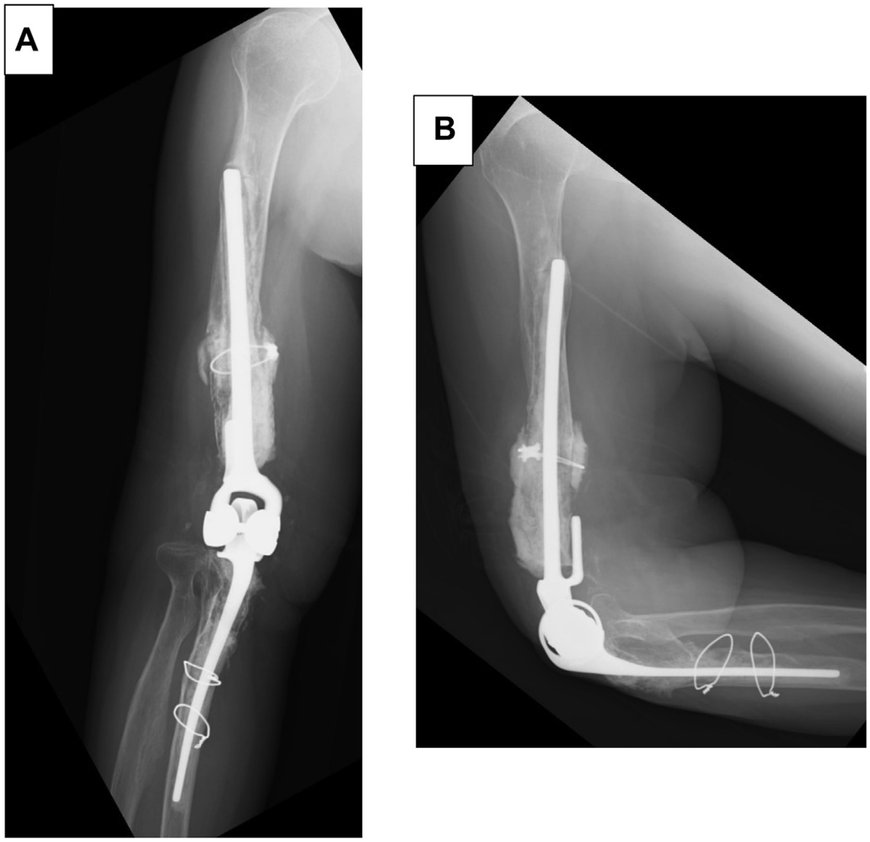

Figure 1 Preoperative X-ray. Five years after the previous operation, anteroposterior (**A**) and lateral (**B**) views show re-loosening of the humeral stem along with varus deformity of the distal cemented part, and perforation of cortical bone at the tip of the stem. No loosening of the ulnar side is observed.

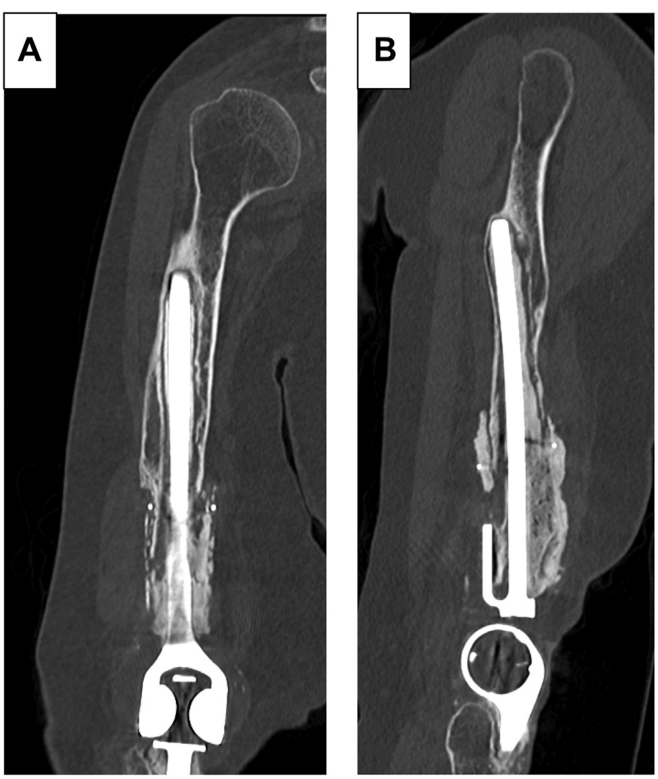

Figure 2 Preoperative CT. Coronal (**A**) and sagittal (**B**) views show a defect in the distal humerus, loosening of the stem, and thinning and perforation of the anterolateral cortex of the humerus. *CT*, computed tomography.

and tendon had disappeared and the TEA component was found out just under the subcutaneous tissue. Although mild metallosis was observed around the TEA component during the surgery, no findings suggestive of infection such as synovial hyperplasia were found, and culture tests of the soft tissue of the surgical field was all negative. The humeral component (Discovery, large size, extra-long stem; Lima Corp., Udine, Italy) (Fig. 3, *A*) was resected and all around the proximal humerus was peeled out, but marked bone loss was apparent from the distal diaphysis to the metaphysis, extending approximately 8 cm in length (Fig. 3, *B*). Under fluoroscopy, the medullary canal of the proximal humerus was fully opened with resection of the septum. For reconstruction of the distal humerus, we used allografted distal femur provided by KUBB (Fig. 4, *A*). The length and shape of the allograft bone were processed using the stem trial (Fig. 4, *B*). After fixing the 12-hole low contact locking compression plate (LC LCP, Depuy Synthes, Raynham, MA, USA) plate (Depuy Synthes, Raynham, MA, USA) to the allograft bone with two mono-cortical screws and one wire placed on the anterolateral side of the proximal humerus, because longer stems have not yet been approved for use in Japan, a humeral component of the extra-long stem that was the same size as the removed stem was fixed to the allograft with bone cement so that an allograft-prosthesis composite (APC) was created. Subsequently, the humeral stem was fixed to the proximal humerus applying the impaction bone grafting (IBG) method using bone chips of the femoral head allograft. As with the resection of the septum, the medullary canal and cortical perforation of the humerus were confirmed under fluoroscopy and direct vision, and then filled the medullary cavity with allogeneic cancellous bone. The plate fixed to the APC was slid into the front of the proximal humerus, and then the proximal humerus and plate were fixed with 2 bi-cortical

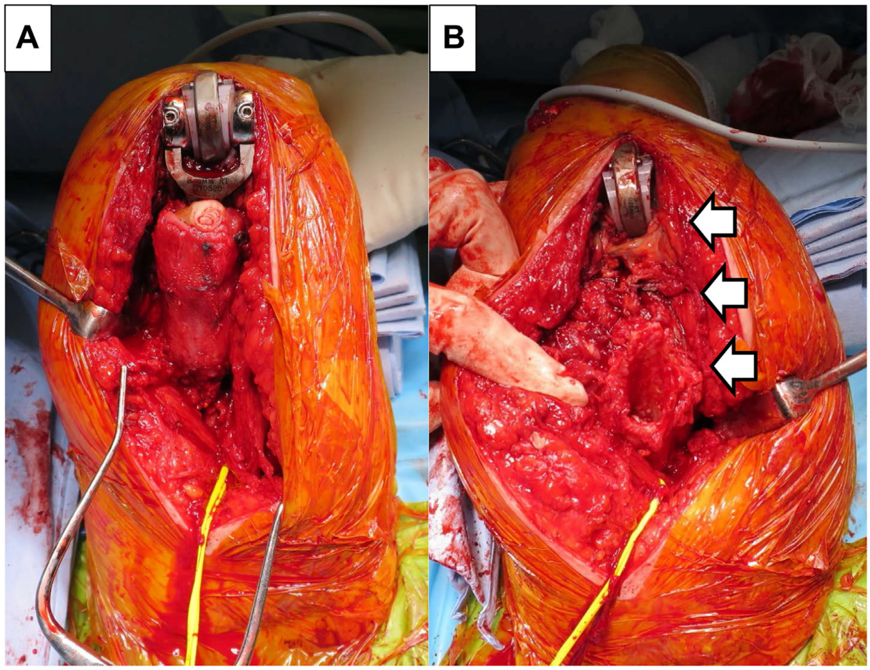

Figure 3 Intraoperative findings. Under general anesthesia, surgery is performed in the supine position with a posterior approach. (**A**) Soft tissue is dissected to expose the distal humerus. (**B**) The humeral component is removed, showing a bone defect about 8 cm in length (white arrow).

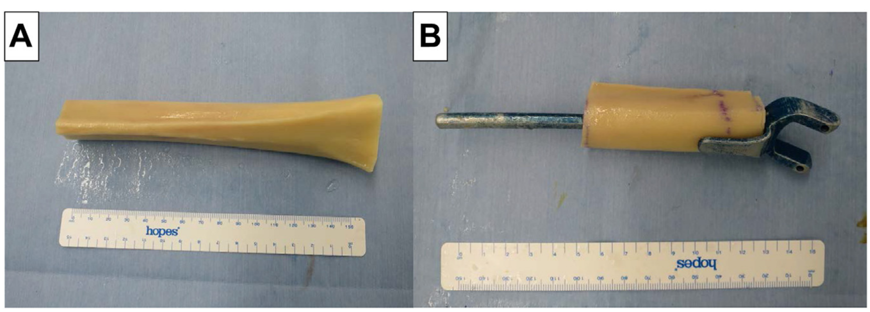

Figure 4 Distal femur allograft. (**A**) Allograft bone from the distal femur provided by the Kitasato University Hospital Bone Bank (KUBB) is used. (**B**) A stem trial is used to process the length and shape of the allograft.

screws and 1 wire through the incision of anterior approach (Fig. 5, *A*). Vancomycin impregnated bone cement (Simplex P 40 g + vancomycin 1 g) was used when creating APC and performing IBG, to prevent infection. Because no loosening of the ulnar side was observed, the ulnar component or its polyethylene was not exchanged. After connecting the humeral component with the ulnar component (Fig. 5, *B*), we confirmed that 110° of flexion and −15° of extension were possible during the surgery. The wound in the posterior soft tissue of the elbow joint was closed with only subcutaneous tissue and skin. Although the soft tissue was somewhat tense, it was possible to close the wound by dissecting the subcutaneous tissue.

Postoperative results

Postoperative X-ray showed good placement of the APC, IBG, and plate (Fig. 6, *A* and *B*). The postoperative course was favorable and the Mayo Elbow Performance Score and Japanese Orthopaedic Association-Japan Elbow Society Elbow Function Score at 3 years postoperatively were 70 and 73, respectively. Range of motion was 105 degrees of flexion and −15 degrees of extension. X-ray at 3 years after surgery showed to be stable at the contact area between native bone and APC, and the area around the intramedullary stem with IBG, with no loosening of the components or resorption of allograft bone (Fig. 7). The right upper arm was slightly shortened compared to the healthy side but with no significant change from before surgery, and follow-up was continued using an elbow joint brace (Fig. 8).

Discussions

In this case, good treatment results were obtained for loosening of the TEA humeral component with a significant bone defect in the distal humerus that was reconstructed using an APC with allogeneic bone from the femoral shaft, the IBG method, and a locking plate. The allogenic femur obtained from KUBB was the distal 1/2 metaphysis of the femur, and the metaphysis was considered too thick to be used in the upper arm. Therefore, only the allogeneic femoral shaft was used as the APC, and locking plate fixation was added to firmly fix the proximal humerus and APC with the IBG. Locking plate fixation and IBG may be useful as a method of fixation between the APC and host bone.

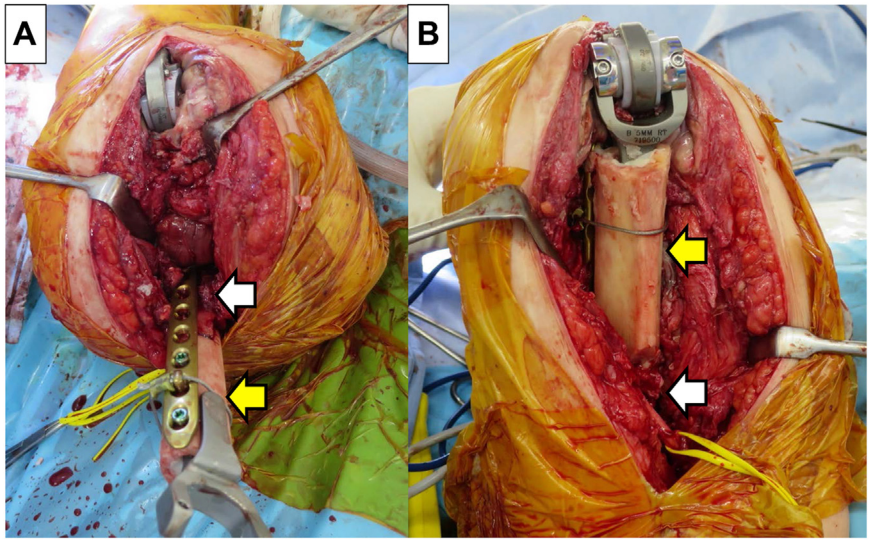

Figure 5 Intraoperative procedure. (**A**) After creating the allograft-prosthesis composite (APC), the humeral stem is fixed to the proximal humerus using impaction bone grafting (IBG), then the proximal humerus and plate are fixed with a cable and screws from the anterior approach. (**B**) The humeral component is connected with the ulnar component and the range of motion is confirmed as relatively good (110° of flexion and −15° of extension). Yellow arrow: APC; white arrow: proximal humerus.

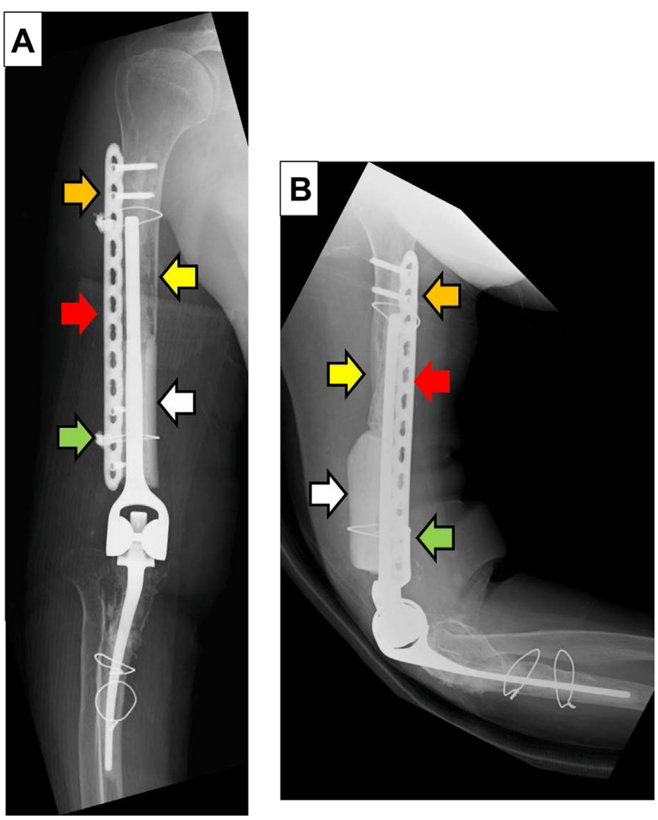

Figure 6 Postoperative X-ray. Anteroposterior (**A**) and lateral (**B**) views show appropriate placement of the allograft-prosthesis composite (APC), impaction bone grafting (IBG), and plate. Red arrow: locking plate; white arrow: APC segment; green arrow: mono-cortical screws and a wire; yellow arrow: IBG segment; orange arrow: proximal bi-cortical screws and a wire.

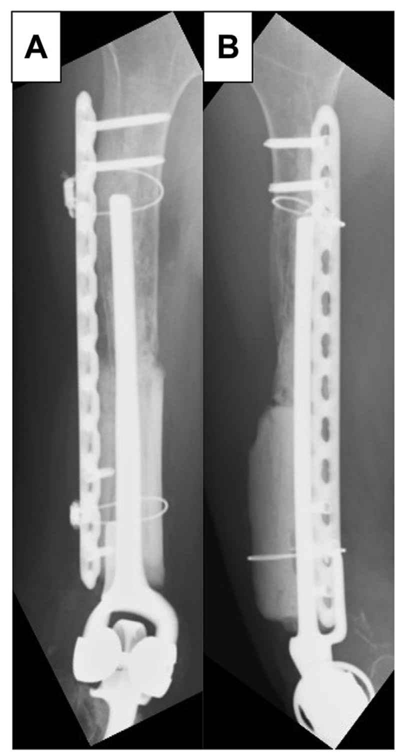

Figure 7 X-ray at 3 years postoperatively. In anteroposterior (**A**) and lateral (**B**) views, the contact area between native bone and allograft-prosthesis composite (APC), and the area around the intramedullary stem with impaction bone grafting (IBG) are stable and no loosening of components or bone resorption of allograft are observed.

Autologous bone grafting,[5] allograft bone,[6-8] custom-made TEAs and TEAs for tumors[3] have been reported as treatments for bone defects in TEA revision surgery. Lee et al[5] investigated 10 patients who underwent TEA revision surgery using an autologous fibular strut and iliac bone for large bone defects around the TEA. Relatively good stem fixation and bone union were obtained and the method was concluded to be effective. On the other hand, regarding the reconstruction of bone defects using APC, several reports including mid-term results have shown the utility of this method,[1,4,6,7] which can be considered if allograft bone is available. In this case, in addition to the distal humeral diaphyseal defect, the proximal intramedullary bone defect was observed and no loosening was observed on the ulnar side, so the reconstruction was performed in combination with APC and IBG with allograft of the femur as available in Japan. Three years postoperatively, no bone

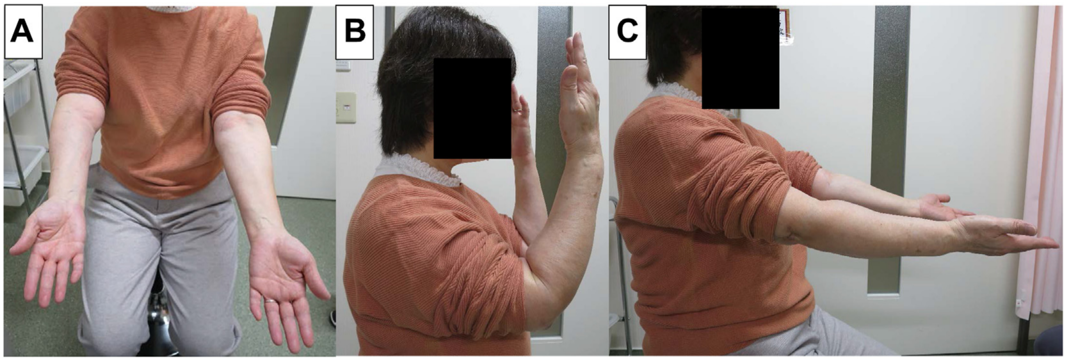

Figure 8 Appearance 3 years after surgery. Positions of the elbow in extension (**A** and **C**) and flexion (**B**). Shortening of the upper arm is observed and active extension is difficult, but shows no change from before surgery. Follow-up has been continued using a right elbow brace.

resorption of the allograft bone is observed and the contact area between native bone and APC, and the area around the intramedullary stem with IBG are stable.

In TEA revision surgery with a large bone defect, most reports have stated that fixation between host bone of the humerus or ulna and the APC has been achieved using a conventional (nonlocking) plate or cerclage wire with the step-cut technique. Manasatt et al[6] reported 13 cases using the step-cut technique, circular wires, and plates to fix APCs, and confirmed the usefulness of these measures. Morrey et al[7] categorized fixation methods for APC into three types, and reported favorable treatment results by performing wire fixation with host bone according to the bone defect. Allograft bone from the same site as the defect, such as the distal humerus or proximal ulna, seems useful when available. However, diaphyseal allograft bones that can be used in Japan are limited to only the femur or tibia.[9] As in previous reports, the method of forming the femoral diaphyseal allograft in a step-cut and achieving fixation with wire was considered, but the bone of the femoral diaphyseal allograft was very hard and considered unsuitable for the formation of complicated structures. Furthermore, when overlapping with the humerus for fixation, the structure becomes quite bulky and requires expansion to the central side and development of a fixation method, so the indications are limited. However, the use of femoral diaphyseal allograft to compensate for bone defects of the humerus raises concerns about discrepancies in the shape or diameter of the stump, and the presence of a component stem makes bi-cortical screws difficult to use. Considering these factors, use of a locking plate, locking screws (mono- or bi-cortical), and cable wiring system allows good fixation of the APC to the host bone. Good bony union of the IBG around the stem was achieved during the clinical course in this case. The locking plate system is useful as a fixation option for host bone and APC.

The limitations of this study were that it was a case report with short-term results of only 3 years and postoperative computed tomography evaluation for bone union was not performed. We will continue follow-up in the future.

Conclusion

A loosened TEA humeral component was able to be reconstructed with a significant bone defect in the distal humerus by combining the APC with a femoral allograft bone, the IBG method, and the locking plate system. For TEA loosening with significant bone defect, if TEA for a tumor is difficult to use for various reasons, reconstruction using allograft bone and a locking plate provides a useful alternative.

Acknowledgment

The authors would like to thank Professor Katsunori Inagaki from Showa University School of Medicine and Professor Katsufumi Uchiyama from Kitasato University School of Medicine, who suggested the operative procedure for this case. They would also like to thank the Kitasato University Hospital Bone Bank (KUBB) and their staff, who managed and provided bone allografts for the patient.

Disclaimers:

Funding: No funding was disclosed by the authors.
Conflicts of interest: The authors, their immediate families, and any research foundations with which they are affiliated did not receive any financial payments or other benefits from any commercial entity related to the subject of this article.
Patient consent: Verbal and written consent was obtained from the patient prior to the preparation of this manuscript.

References

1. Amirfeyz R, Stanley D. Allograft-prosthesis composite reconstruction for the management of failed elbow replacement with massive structural bone loss: a medium-term follow-up. J Bone Joint Surg Br 2011;93:1382-8. https://doi.org/10.1302/0301-620X.93B10.26729.
2. Davey MS, Hurley ET, Gaafar M, Molony D, Mullett H, Pauzenberger L. Long-term outcomes of total elbow arthroplasty: a systematic review of studies at 10-year follow-up. J Shoulder Elbow Surg 2021;30:1423-30. https://doi.org/10.1016/j.jse.2020.11.014.
3. Gautam D, Arora N, Gupta S, George J, Malhotra R. Megaprosthesis versus allograft prosthesis composite for the management of massive skeletal defects: A meta-analysis of comparative studies. Curr Rev Musculoskelet Med 2021;14:255-70. https://doi.org/10.1007/s12178-021-09707-6.
4. Laumonerie P, Granjou J, Tibbo ME, Massin V, Bonnevialle N, Mansat P. Midterm outcomes allograft prosthetic composit reconstruction for massive bone loss at the elbow. Orthop Traumatol Surg Res 2022;10:103517. https://doi.org/10.1016/j.otsr.2022.103517.
5. Lee YM, Son SH, Sur YJ, Song SW. Reconstruction of large bone defect using autogenous fibular strut and iliac bone graft for revision total elbow arthroplasty. Medicine (Baltimore) 2021;100:e28054. https://doi.org/10.1097/MD.0000000000028054.
6. Mansat P, Adams RA, Morrey BF. Allograft-prosthesis composite for revision of catastrophic failure of total elbow arthroplasty. J Bone Joint Surg Am 2004;86:724-35. https://doi.org/10.2106/00004623-200404000-00009.
7. Morrey ME, Sanchez-Sotelo J, Abdel MP, Morrey BF. Allograft-prosthetic composite reconstruction for massive bone loss including catastrophic failure in total elbow arthroplasty. J Bone Joint Surg Am 2013;95:1117-24. https://doi.org/10.2106/JBJS.L.00747.
8. Rhee YG, Cho NS, Parke CS. Impaction grafting in revision total elbow arthroplasty for aseptic loosening and bone loss: surgical technique. JBJS Essent Surg Tech 2013;3:e17. https://doi.org/10.2106/JBJS.ST.M.00018.
9. Uchiyama K, Inoue G, Takahira N, Takaso M. Revision total hip arthroplasty - salvage procedures using bone allografts in Japan. J Orthop Sci 2017;22:593-600. https://doi.org/10.1016/j.jos.2017.01.023.