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Compressive osseointegration endoprosthesis for massive bone loss in the upper extremity: surgical technique

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Background: Reconstruction of large segments of bone loss can be very difficult. The use of a prestressed ingrowth implant can offer an attractive surgical option in these challenging cases.
Methods: This report describes the surgical technique in depth, combining the experience of the authors. Nuances of the technique are emphasized.
Results: Although published reports are uncommon, long-term restoration of extremity function is possible with this technology.
Conclusions: The use of compressive osseointegration endoprostheses is not yet widespread in the upper extremity, but this technology adds to the host of surgical options for managing massive bone loss and difficult revision surgery.

The need to reconstruct the humerus after segmental bone loss is, fortunately, relatively uncommon. It can present, however, from such conditions as resection for an extremity neoplasm, traumatic injury to the extremity, and as a sequelae of aseptic or septic loosening of prosthetic implants. Options for management include use of an allograft prosthetic composite, osteoarticular graft, and modular or custom devices.[3,4,18,21,22,24] A short remaining segment of native bone presents additional challenges in satisfactory implant fixation in the near and far time frames. In such circumstances, a prestressed ingrowth implant (Compress; Zimmer Biomet, Warsaw, IN, USA) has been successfully used to reconstruct massive segments of bone loss in the lower extremity and more recently has been described in the upper extremity.[10,13,14] This report describes the nuances of the use of such a device in the upper extremity.

Materials and methods

Indications

The indication for the use of this technology is the existence of limited remaining bone stock. As noted, this could be from traumatic bone loss, resection of tumor, or after prior arthroplasty. If the remaining bone from these conditions jeopardizes the secure placement of a new implant, then a compressive osseointegration implant offers an attractive option for reconstruction (Figs. 1 and 2). The technology is contraindicated if the remaining bone is too short in length (generally <5 cm of remaining bone) or of such poor quality that it cannot withstand the application of the compressive load (residual cortex thinner than 2.5 mm). These devices are also inappropriate in the presence of infection or an uncooperative patient.

Set up

The procedure is typically performed with a combination of general anesthesia and a preoperatively administered interscalene block to aid in postoperative analgesia. The patient is placed in the beach chair position, with the head and trunk elevated approximately 45°. The patient's head is secured in the neutral position to minimize traction on the brachial plexus during the procedure. Preserving the ability to extend the shoulder intraoperatively is critical because this is necessary to instrument the humeral canal. Shoulder extension can be maintained by translating the patient's trunk laterally to the side of the operative table or by using a table breakaway attachment, as is our preference (Skytron Beach Chair, Grand Rapids, MI, USA).

Exposure

Surgical exposure of the humerus revolves around 2 standard approaches. A crucial concept in exposure is the need to circumferentially control the remaining portion of the humeral shaft for safe insertion of the locking pins. This length depends on the spindle chosen. Our experience is with the short spindle

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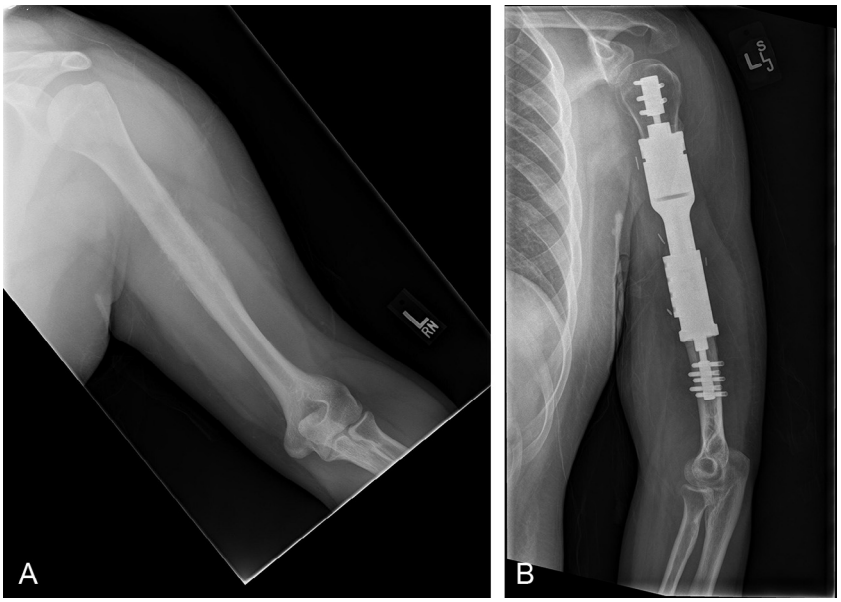

Figure 1 (**A**) A 22-year-old man with stage IIB Ewing sarcoma of his humerus underwent radical resection. Because of the limited remaining bone stock, an intercalary prosthesis with Compress (Zimmer Biomet, Warsaw, IN, USA) was implanted. (**B**) Postoperative radiographs at 41 months reveal a stable reconstruction.

necessitating approximately 5 cm of access; the standard spindle is approximately twice that length. Subperiosteal exposure of the bone for that length is not necessary but rather exposure and control of any neurovascular structures to avoid injury during bicortical pin insertion. For proximal humeral or long distal humeral resections, an extended deltopectoral approach is used. This approach will comfortably expose the proximal two-thirds of the humeral shaft. Given that this implant is designed for use in circumstances with short to very short bone segments, further distal exposure is commonly necessary.

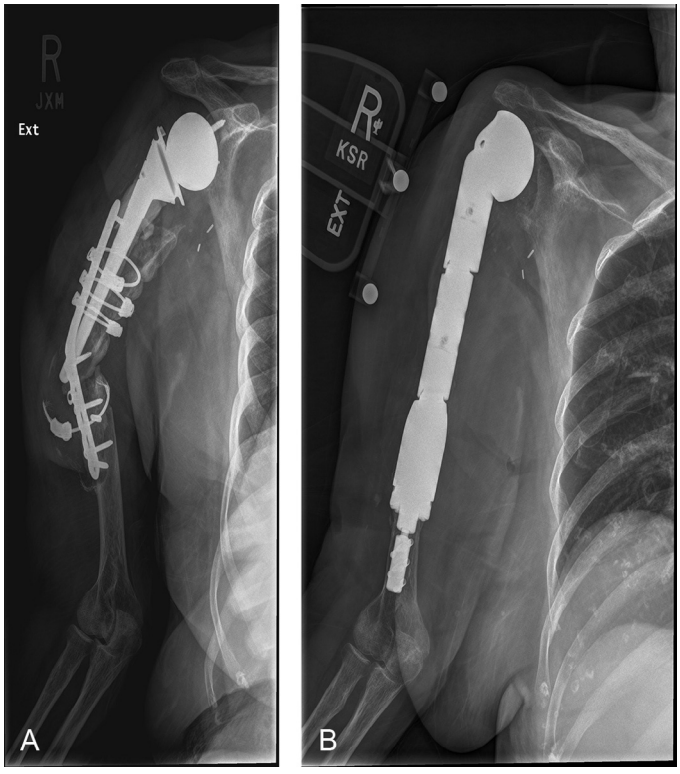

Figure 2 (**A**) A 73–year-old woman had an infected periprosthetic fracture nonunion with a loose humeral component of her reverse shoulder arthroplasty. (**B**) This led to a 2-stage revision arthroplasty. At 36 months she remained infection and pain free.

In this circumstance, a second posterior approach is used, splitting the raphe between the long and lateral heads of the triceps. Because both this incision and the anterior incision with the anterolateral approach are longitudinal and separated by a wide skin bridge, both approaches can be safely used in the same procedure. As the long and lateral heads are split, the radial nerve can and should be identified in the spiral groove. Mobilization of the neurovascular bundle allows safe instrumentation of the humerus distally. After the distal humeral segment is reamed and the anchor spindle applied, the spindle-humeral shaft construct is passed forward to the anterior incision for completion of the implant assembly.

Humeral canal preparation

Identifying an area of the humeral shaft where the implant will have circumferential or near circumferential bony support is essential. The shaft should also be of sufficient thickness to support the compressive loads across the implant. This is generally considered to be a minimum of 2.5 mm, although a long 13-hole anchor plug is made for cortical thickness down to 1.0 mm. A small area of circumferential bone loss or thinning can be accepted; however, we will accept bone deficiency over no more than 10% of the shaft circumference.

The humerus is then transversely cut at this level. The level of the cut should also be made taking into consideration the implant options for eventual reconstruction (Figs. 3 and 4). A spindle trial can be used in conjunction with other implant trials to approximate the length of the final construct. The Compress system is designed to link with the Comprehensive Segmental Revision System (Zimmer Biomet), allowing creation of a proximal humeral replacement or total elbow arthroplasty. Alternatively, custom adaptors can be fashioned to couple with other endoprosthetic implants. If the available implant options do not allow a satisfactory final prosthetic length, then adjustment of the osteotomy level should be done before placement of the anchor plug. Once the plug is secured with