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CORR Insights

CORR Insights®: Use of Compressive Osteointegration Endoprostheses for Massive Bone Loss From Tumor and Failed Arthroplasty: A Viable Option in the Upper Extremity

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Where Are We Now?

Limb salvage is possible and appropriate in up to 90% of patients with primary sarcomas of the extremities without compromising survival, and this approach achieves almost equal local tumor control when compared to amputation [8], with better functional results. With continuous improvement in survival of patients with metastatic disease, more of these patients are candidates for tumor resection and limb salvage, particularly those with oligometastatic disease [6, 7]. An increasing number of patients with massive bone loss resulting from trauma, osteomyelitis, and failed arthroplasty are being treated with endoprostheses.

In order to retain a functional limb following bone and/or joint resection, a durable structural reconstruction is required. Reconstruction options include biologic and endoprosthetic solutions, neither of which is entirely satisfactory. Complications related to the use of endoprostheses include infection, aseptic loosening of prosthetic stems, prosthetic fractures, and joint instability [5]. Intramedullary endoprosthetic fixation, whether achieved by cementing or press-fit, can fail in up to 30% of patients, particularly among patients undergoing knee or elbow reconstructions [5, 7].

The use of compression osteointegration (Compress® Compliant Prestress Device [CPS]; Biomet Inc, Warsaw, IN, USA) as a fixation method was introduced, in part, to reduce the risk of aseptic loosening. This technique creates continuous stable high-grade compression forces between the cut bone end and a porous, coated disc or spindle. This compression stimulates osteointegration at the bone-prosthetic interface, avoids stress stem shielding around the stem, prevents osteolysis from particulate wear debris, and preserves bone stock, all of which contribute to a reduction in the likelihood of aseptic loosening. The short intramedullary

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component permits its use in situations where there is limited bone remaining. In reconstructions complicated by aseptic loosening, little bone is lost in the course of revision. For infections, an exchange of the extraosseous portion of the endoprosthesis often can be done, leaving the fixed anchor plug and spindle in the bone while still allowing effective treatment of the infection.

In a large series with long-term followup, Healey and colleagues [4] showed that the efficacy of this fixation technique in the lower limb is at least as successful (and probably superior to) conventional methods. While we have seen similar results in the lower limb, we still have much to learn regarding its use in the upper extremity [3, 4, 10].

Where Do We Need To Go?

Clearly, more studies examining upper-extremity fixation with greater patient numbers and longer followup are necessary. Although the current study reports on a small heterogeneous patient population undergoing upper extremity fixation, the paper is timely. In their discussion, Goulding and colleagues state that one of the limitations of their study is that the majority of the patients underwent complex reconstructions in grossly compromised bone, some still containing cement. However, the fact that this form of reconstruction was possible, and largely successful in such cases, is arguably a strength rather than a weakness. All but two patients had previous surgery, yet only two of eight patients suffered complication directly related to failure of the CPS implant—namely, failure of ingrowth at the bone-implant interface, resulting in periprosthetic structural failure similar to that reported in previous studies [4, 5].

It should be noted that none of the patients reported in the study by Henderson and colleagues [5] had CPS fixation. Furthermore, both patients had multiple previous procedures, so careful study of these patients and the surgical techniques employed may point the way to improvement. For instance, constant bone irrigation while using the face reamer may prevent osteonecrosis.

The current study highlights the suitability of the CPS system for fixation in situations where there is minimal residual juxta-articular bone, precluding use of a conventional stem. Further studies, both clinical and in the laboratory, are necessary in order to establish guidelines as to the minimal amount of residual bone necessary to achieve successful fixation. In one of the reported cases in this paper, a custom Compress® CPS was used in order to gain fixation in the ulna. It is possible that a greater selection of anchor plug sizes would lead to greater versatility in the use of the CPS system in the upper limb. Additional research is needed to gain greater guidance regarding the ideal pressure applied at the bone-spindle interface and the minimal number of pins necessary.

To date, there have been no satisfactory solutions to address the high failure rates of fixation in elbow replacement using conventional stabilization methods [2]. Judicious use of the CPS system may be effective in reducing complications in this situation. Drawing on the satisfactory results of the use of the CPS system in the lower limb, it seems reasonable to expand its use in the upper limb. This study should lead the way in its use following resection of primary or solitary metastatic bone lesions in the humerus, even in those that could be reconstructed using conventional methods. Since the proximal humerus is a common site for both primary and metastatic tumors, it should be feasible to accumulate a considerable number of cases to carry out a multicenter or even a single-center study to assess the efficacy of the CPS system in the humerus. A study with greater numbers would also permit assessment of the success using this device for different pathologies and different anatomic sites in the humerus. Use of the CPS system in reconstruction

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following diaphyseal resection is an attractive application. A recent publication by Benevenia and colleagues [1] reported satisfactory results using cemented intercalary prostheses in the humerus. However, most of these patients had metastatic disease and followup was short. The use of the CPS device in the management of infected prostheses requires further study.

How Do We Get There?

Goulding and colleagues have led the way by undertaking a multicenter study, which should be complemented by future prospective studies. Ideally, a randomized trial should be done to compare CPS fixation to conventional stabilization. In the past, an attempt was made to initiate a prospective study comparing CPS and cemented fixation in the distal femur, as proposed by Healey and colleagues [4], but the trial proposal was ultimately not adopted by the participants in the FDA Registration Trial. Therefore, a stronger commitment to such randomized clinical investigation by the orthopaedic surgical oncology community is not realistic.

A possible solution to this dilemma could be to adopt the recommendations of the Expert Panel Consensus Meeting held in October 2016. This international panel of 44 orthopaedic oncology specialists was convened by the Prophylactic Antibiotic Regimens in Tumor Surgery (PARITY) Investigators to establish research priorities in musculoskeletal oncology [9]. The recommendations, according to experts on the panel with whom I've spoken, would prioritize the creation and maintenance of a registry of reconstructive procedures and implants to facilitate outcomes research. This registry would constitute a practical alternative to the impractical, albeit ideal, randomized multicenter trial, and uncommon surgical procedures would be suitable for investigation under this approach. For example, the CPS design could be compared to other implants used for large humeral constructions. The influence of radiation and chemotherapy on outcome could be studied in a similar manner. These would be valuable first steps toward addressing the current knowledge gaps in the surgical management of upper extremity bone lesions. It must be emphasized, however, that active participation of the orthopaedic oncology community will be the most important determinant of our success in achieving these goals.

References

1. Benevenia J, Kirchner R, Patterson F, Beebe K, Wirtz DC, Rivero S, Palma M, Friedrich MJ. Outcomes of a modular intercalary endoprosthesis as treatment for segmental defects of the femur, tibia, and humerus. *Clin Orthop Relat Res.* 2016;474:539–548.
2. Funovics PT, Schuh R, Adams SB Jr, Sabeti-Aschraf M, Dominkus M, Kotz RI. Modular prosthetic reconstruction of major bone defects of the distal end of the humerus. *J Bone Joint Surg Am.* 2011;93:1064–1074.
3. Goldman LH, Morse LJ, O'Donnell RJ. Wustrack RL. How often does spindle failure occur in compressive osseointegration endoprostheses for oncologic reconstruction? *Clin Orthop Relat Res* 2016;474:1714–1723.
4. Healey JH, Morris CD, Athanasian EA, Boland PJ. Compress knee arthroplasty has 80% 10-year survivorship and novel forms of bone failure. *Clin Orthop Relat Res.* 2013;471:774–783.
5. Henderson ER, Groundland JS, Pala E, Dennis JA, Wooten R, Cheong D, Windhager R, Kotz RI, Mercuri M, Funovics PT, Hornicek FJ, Temple HT, Ruggieri P, Letson GD. Failure mode classification for tumor endoprostheses: retrospective review of five institutions and a literature review. *J Bone Joint Surg Am.* 2011;93:418–429.
6. Lin PP, Mirza AN, Lewis VO, Cannon CP, Tu SM, Tannir NM, Yasko AW. Patient survival after surgery for osseous metastases from renal cell carcinoma. *J Bone Joint Surg Am.* 2007;89:1794–1801.
7. Ratasvuori M, Wedin R, Hansen BH, Keller J, Trovik C, Zaikova O, Bergh

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P, Kalen A, Laitinen M. Prognostic role of en-bloc resection and late onset of bone metastasis in patients with bone-seeking carcinomas of the kidney, breast, lung, and prostate: SSG study on 672 operated skeletal metastases. *J Surg Oncol.* 2014;110: 360–365.

8. Rosenberg SA, Tepper J, Glatstein E, Costa J, Baker A, Brennan M, DeMoss EV, Seipp C, Sindelar WF, Sugarbaker P, Wesley R. The treatment of soft-tissue sarcomas of the extremities: Prospective randomized evaluations of (1) limb-sparing surgery plus radiation therapy compared with amputation and (2) the role of adjuvant chemotherapy. *Ann Surg.* 1982;196:305–315.
9. Schneider P, Evaniew N, Rendon JS, McKay P, Randall RL, Turcotte R, Velez R, Bhandari M, Ghert M, on behalf of the PARITY Investigators. Moving forward through consensus: Protocol for a modified Delphi approach to determine the top research priorities in the field of orthopaedic oncology. *BMJ Open.* 2016;6:e011780.
10. Zimel MN, Farfalli GL, Zindman AM, Riedel ER, Morris CD, Boland PJ, Healey JH. Revision distal femoral arthroplasty with the Compress® prosthesis has a low rate of mechanical failure at 10 years. *Clin Orthop Relat Res.* 2016;474:528–536.