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Category: Interactive Cases

Title:

Preoperative Surgical Margin Assessment Using a Three-Dimensional-Printed Model for Simulated Surgery of Periarticular Malignant Bone Tumors

Significance & Hypothesis/Techniques:

Limb-sparing surgery with joint sacrifice and replacement, as opposed to joint-preservation, is the treatment of choice for periarticular malignant bone tumors due to concerns for positive margins related to tumor margin proximity. Resulting long-term sequelae leads to lifelong disability as the patient outlives the implant lifespan. Attempt at joint-preservation should therefore be made whenever feasible to provide a lifelong biologic solution.

When joint-preservation is considered, surgical margin assessment is therefore critical to ensure success. In addition to MRI, 3D-printed models can greatly improve our understanding of the tumor proximity to the joint. We hypothesized that preoperative simulated surgery using a 3D-printed model will help guide the decision making of joint preservation versus sacrifice and will ensure negative postoperative resection margins.

Innovation:

3D-printed models have been in use for several years, generally used for educational purposes and to guide resection of tumors. Thus far though, there haven't been any documented reports of its use for preoperative simulated surgery in the field of orthopaedic oncology. While digitally simulated procedures are currently offered by some companies, a hands-on, physical simulation has yet to be offered. Hands-on simulation offers significant benefits as opposed to digital, allowing for improved technical considerations of unpredictable obstacles which may arise during surgery, which would otherwise not have been encountered until the day of surgery. These considerations are especially relevant for complex resections and reconstructions requiring allograft and hardware fixation, as is done when treating periarticular malignant bone tumors.

Approach (Materials and Methods):

Three patients with periarticular osteosarcoma involving the distal femur, proximal humerus, and proximal tibia, ages: 14, 13, and 6 respectively, were included. 3D-models were created based on MRI and CT, and printed at 100% scale, color coded for tumor identification. A surgical simulation was then performed, with the final surgical approach determined by the results of the simulation.

Results:

In all cases, preoperative simulation confirmed joint preservation was possible without contamination of the joint. All patients subsequently underwent successful joint preservation surgery via a trans-epiphyseal resection. The final pathologic margins for all cases were negative, and all three joints were successfully preserved with stable reconstructions as per preoperative simulated plans (See fig. 1-3).

Discussion & Impact:

Preoperative planning with a surgically simulated “practice-run” using 3D-printed models successfully correlated with true final surgical margins. All surgical resections were performed as per the preoperative plans without any intraoperative complications. This novel technique provides surgeons with confidence needed in the decision making to proceed with exceedingly risky procedures involving periarticular malignant tumors, while allowing for a smooth intraoperative workflow in the setting of an already practiced surgical procedure. Indications for preoperative “practice-run” simulated surgeries can be further expanded to include all other orthopaedic subspecialties to help improve operative outcomes. Additionally, this technique has significant educational implications and benefits for enhancing technical surgical skills of trainees.

Figure 1: 14yr-old-female with osteosarcoma of the left distal femoral metadiaphysis. Preoperative, 3D-model simulated surgery, intraoperative, and postoperative images.

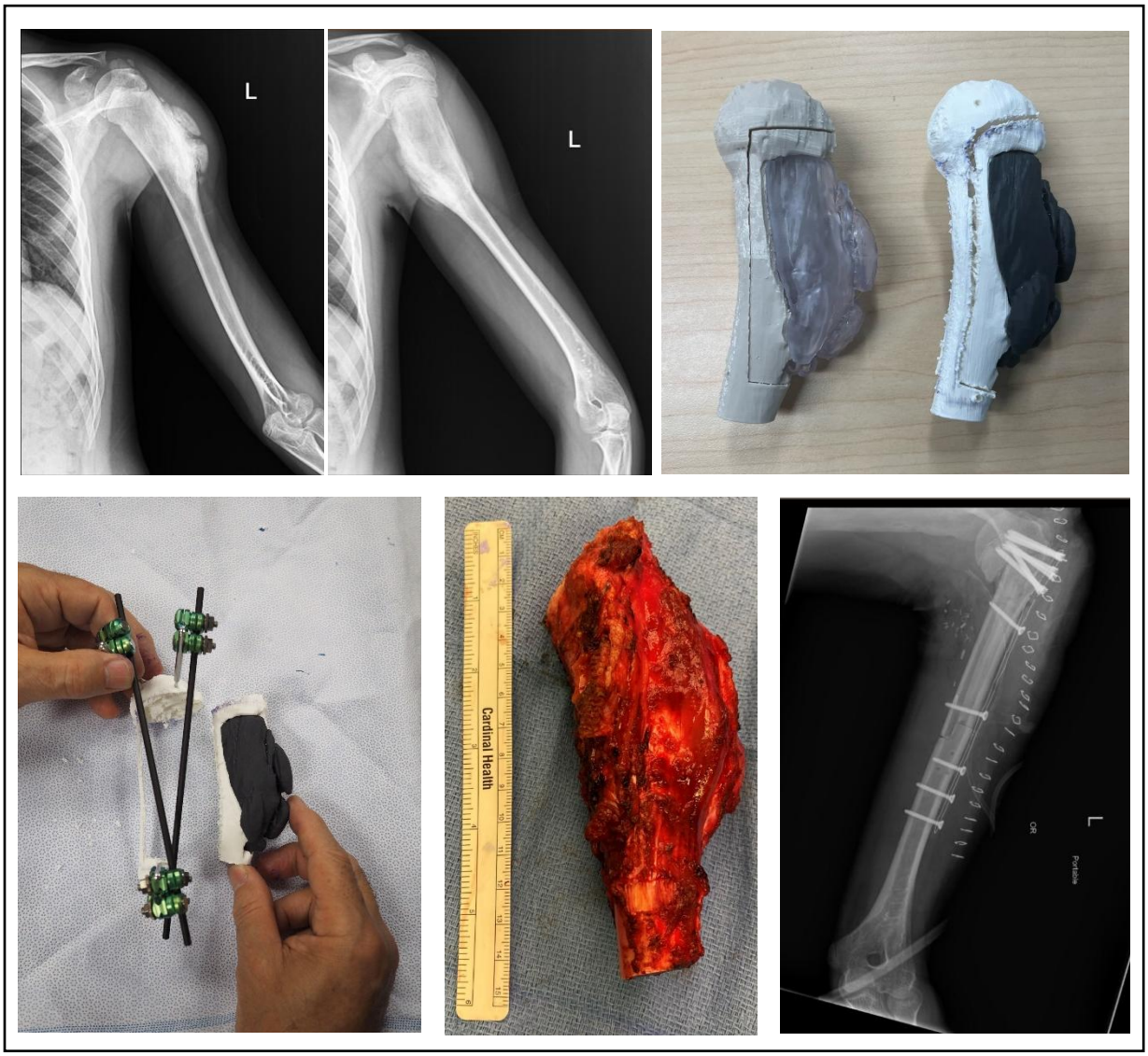

Figure 2: 13yr-old-male with parosteal osteosarcoma of the left proximal humerus. Preoperative, 3D-model simulated surgery, intraoperative, and postoperative images.

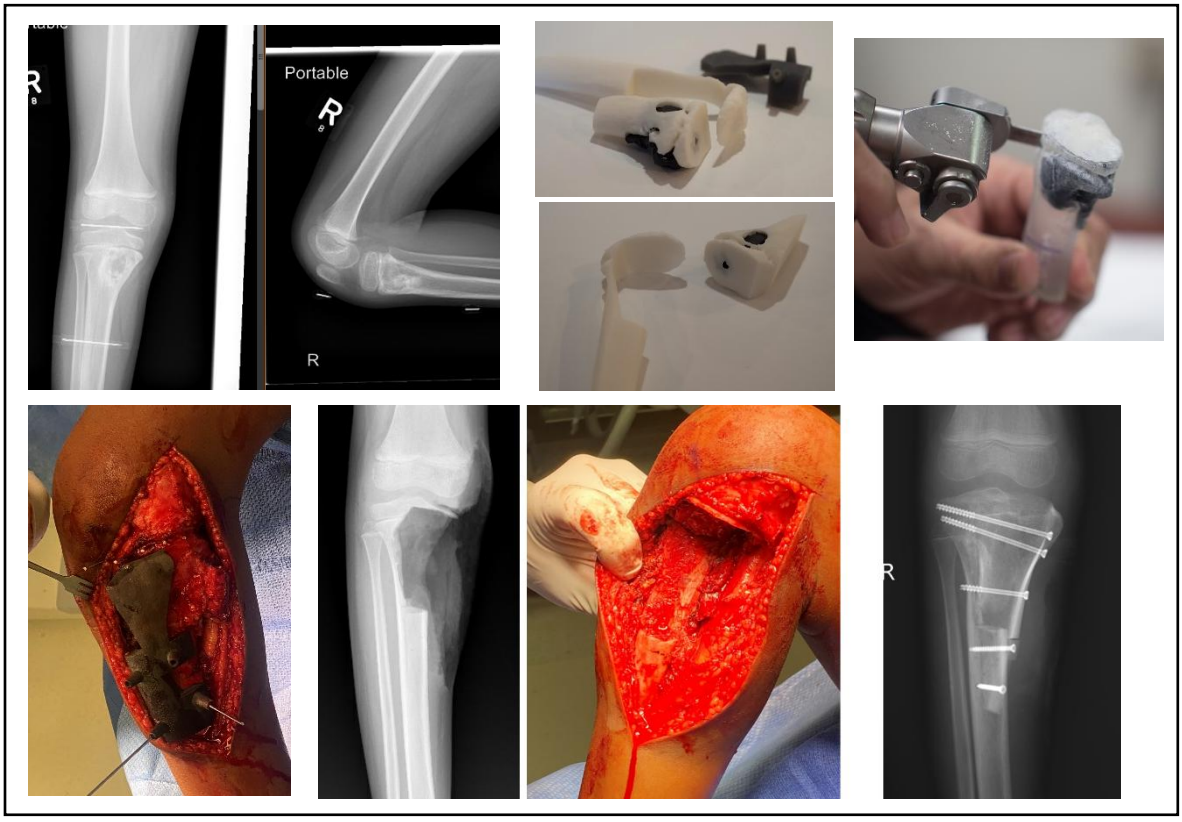

Figure 3: 6yr-old-male with osteosarcoma of the right proximal tibia. Preoperative, 3D-model simulated surgery, intraoperative, and postoperative images.