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3D surgical planning and Patient Specific Instruments (PSIs) can achieve good accuracy for complex bone resections in bone sarcoma patients.

[1]Kwok Chuen WONG, [2]Shekhar-Madhukar KUMTA
[1]Orthopaedic Oncology, Prince of Wales Hospital, Hong Kong
[2]Orthopaedic Oncology, Prince of Wales Hospital, Chinese University of Hong Kong, Hong Kong

Background
Navigation-assisted surgery has been reported to enhance surgical accuracy in bone sarcoma surgery. However, the technique requires bulky facilities, additional personnel to operate on the machine and has a steep learning curve. Patient specific instruments (PSIs) have been used as a simpler alternative in assisting joint arthroplasty and correction of limb deformity. We investigated the use of 3D surgical planning and PSIs in realizing computer planning of complex bone resections in bone sarcoma patients.

Questions/Purposes
We asked
1) what is the accuracy of achieving complex bone resections using 3D surgical planning and PSIs;
2) what is the time required for performing bone resections using PSIs;
3) what are the problems of using PSIs; and
4) what are the early clinical results using the technique.

Patients and Methods
Between September 2011 and July 2014, we have performed 9 bone sarcoma patients with the assistance of 3D surgical planning and PSIs. The mean age of the patients was 30.9 (9 – 64). There were 3 high grade osteosarcoma with neoadjuvant chemotherapy, one high grade chondrosarcoma and 5 low grade bone sarcoma (3 osteosarcoma; 1 chondrosarcoma; 1 fibrosarcoma). Tumor locations were 2 acetabulum, 4 proximal tibia, 2 femur and 1 humerus. Two bone grafts and 7 custom prostheses (2 intercalary; 3 joint-preserving; 2 pelvic) were used. The assistance was thought to be necessary because of anticipated difficulties in achieving an accurate or multi-planar bone resection (7 cases) and in attaining a satisfactory resection plane to accommodate a custom prosthesis (7 cases).
CT/MRI images were imported into an engineering software, MIMICS. Reformatted

images and 3D bone models were generated, in which resection planes were defined. Custom prostheses and PSIs were designed and manufactured for reconstructing bone defects and realizing intended bone resections respectively. Intraoperatively, surgeons executed the intended resections with the assistance of PSIs.

The planned resection was considered accurate if the remaining bone fitted to the custom prosthesis, or the achieved bone resection deviated from the planned one within a difference of 5mm by comparing postoperative CT images or CT images of resected specimens. We recorded the time required for placing PSIs on bone surface and performing bone osteotomies with the assistance of PSIs. The problems of intraoperative use of PSIs were also recorded.

At each follow-up, we looked for local recurrence and recorded the limb function by measuring MSTS scores. We obtained plain radiographs at each visit for assessing the bone formation at bone-implant junctions. Complications were classified according to the International Society of Limb Salvage (ISOLS) classification system.

Results

All bone resections were successfully performed with the assistance of 3D surgical planning and PSIs. The achieved bone resections were accurate as they matched with custom prostheses and deviated from the planned within a difference of 5mm. The mean maximum deviation from the planned was 1.6mm (0.5 – 3.9).

The mean time required for placing PSIs was 5.8 minutes (1 – 10) and performing bone osteotomies with the assistance of PSIs was 4.4 minutes (2 – 6).

One PSI was broken at one cutting slot by the oscillating sawblade during osteotomy. We re-osteotomized in one patient using the same PSI as the initial placement of the PSI was not fully optimal due to soft tissue constraint.

The histological examination of all specimens showed negative resection margin except one patient with a microscopic positive soft tissue margin. At a mean follow-up of 2.2 year (0.8 – 3.7), one pelvic patient died of local tumor recurrence from soft tissue and lung metastases 6 months after surgery. One patient developed a solitary lung metastasis at 20 months after surgery. She is in remission after metastasectomy. The mean MSTS score was 28 (21 – 30). Early loosening at bone-implant junction (Type 2A) was observed in two cases. Both were treated with early bone grafting. No other complications were noted.

Conclusions

The achieved accuracy suggested that 3D surgical planning and PSI may be a viable method of reproducing complex bone resections in patients with bone sarcoma. The mean time for placing PSIs and performing osteotomies were about 10 minutes that

was clinically practical. Intraoperatively, how to verify the correct placement of PSIs as planned needs further research. Stronger materials or metal sleeves at cutting slots may prevent breakage of PSIs. Comparative studies with conventional or navigation methods are required to evaluate the clinical efficacy of the new technique.