Computer assisted means of resection and reconstruction in bone tumor surgery

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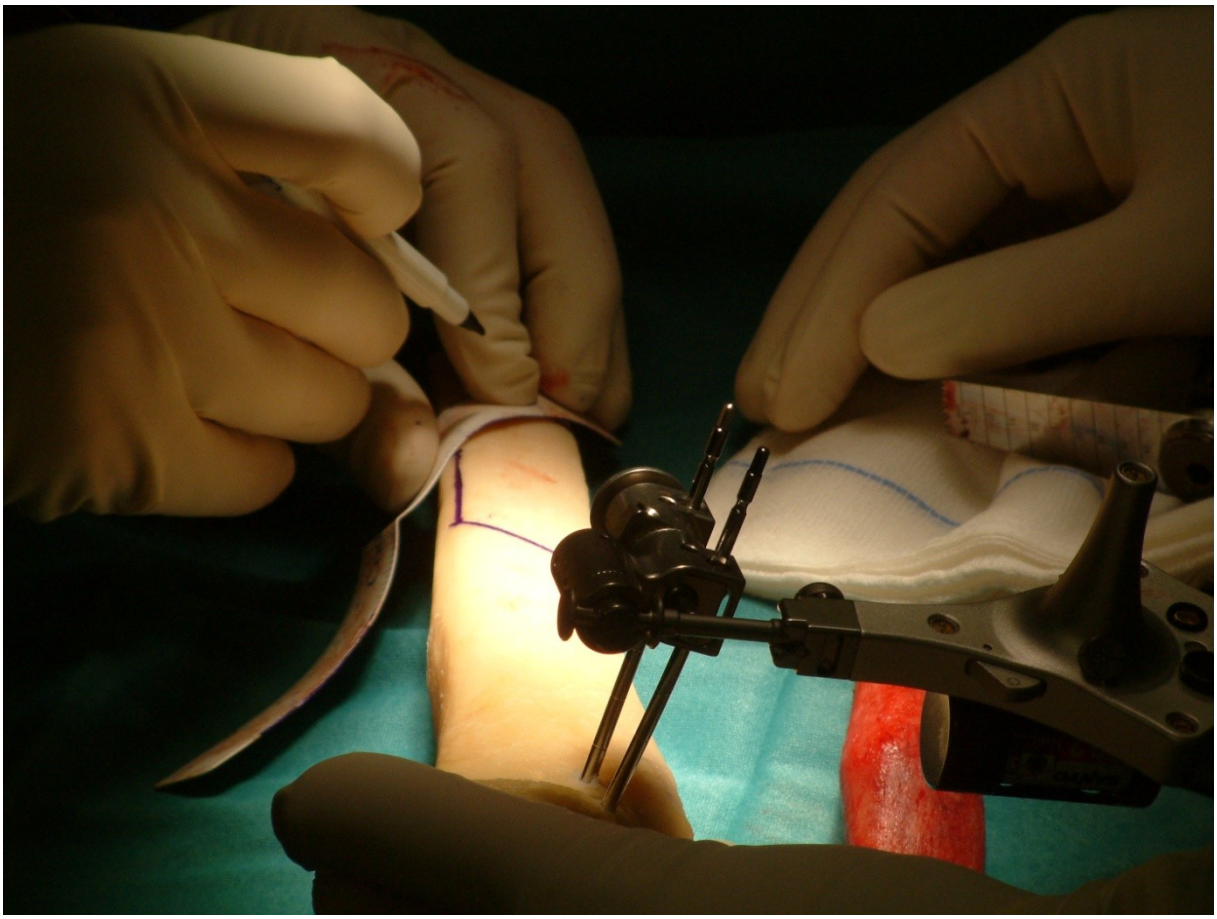
In the treatment of bone tumors margins are very important. The first goal is always to obtain an adequate margin. Resection of for example bone tumors results in defects that require reconstruction, the larger the defect, the more difficult the reconstruction and generally speaking the poorer the function. The reconstruction and post op period are often difficult due to allograft formation difficulties and complications as long in growth time, infections and fractures.

The use of computer assisted surgery (CAS) navigation systems can be an elegant alternative to the standard approach of fluoroscopy assisted resection and unassisted reconstruction. CAS has already been described as able to reliably plan resection planes creating adequate margins in bone tumor operations [1]; furthermore it can be used to perform the reconstruction with pre-planned resection planes. As an example, CAS resection and reconstruction can be applied to hemicortical resections.



Some low grade bone tumors can be resected close to the tumor leaving a partial defect in the host bone instead of a segmental defect. The reconstruction can be done with a so-called inlay graft. In low grade malignant tumors margins can be smaller, resulting in less tissue damage, smaller defects and better functional outcome. Hemi-cortical resections leave the cortex partially intact as a natural splint. This surgical technique for the treatment of low grade malignant bone tumors was first described in

1982 by Campannaci et al. Hemicortical resection is considered a safe alternative to a larger segmental resection for low malignant bone tumors. However the operation is technically demanding and complications as fractures are reported. [2]

First a fresh frozen donor bone has to be found in the bone bank with, optimally, comparable dimensions to the host bone. A CT-scan of the same configuration (i.e. slice thickness) is then performed from both the host and the allograft. These scans are imported in the CAS system and matched by hand to find the optimum overlay in order to find the best fitting part to take the inlay graft from. The planned resection planes from the setup of the host bone are then copied to the setup of the allograft.

Normal CAS setup is performed with a tracker attached to the bone after exposure of the bone. Matching is done with reference point, and surface matching, till an accurate match is reported. The pointer tool is used to identify and mark the edges and entry points of the planned trapezoid shape. The excision planes are marked with a pen and checked with the pointer tool for accuracy. An oscillating bone saw is used to perform the preplanned trapezoid shaped resection. The resection planes were checked again after resection for accuracy. The exact same procedure can then be performed on the allograft bone.

The means of using CAS in the reconstruction after tumor resection is relatively new in orthopedics; in craniomaxillofacial surgery it is becoming more common. Last year we reported one case of CAS resection and reconstruction in an ademantinoma, in a 12 year old boy. The result was a good fit of the allograft, with rapid in growth. Currently we have operated three patients all with benign bone tumors, all with good follow-up, using the computer assisted hemicortical resection and allograft reconstruction approach. A fourth is planned in a short period. CT controls are currently being performed as to quantify the accuracy of allograft reconstruction. Results are not available yet but we hope to analyze these soon. In our opinion the CAS approach to these, albeit rare conditions, is an improvement over the current approach. The time required for the surgery is greatly reduced, and the difficulty is decreased. We hypothesize that the increased accuracy in navigation decreases the gap between the allograft and the host bone, promoting faster in growth and possibly lower fracture rates. It proves that CAS can be used in all kinds of bone reconstructive surgery.

Other alternatives for an assisted reconstruction can be pre planned saw blocks designed for both the patient bone and the allograft bone. CAS Navigation in this setting would in our eyes still be required in attaining an accurate placement of the saw block. As the blocks are custom made this can be quite expensive. Another alternative is the pre fabrication by rapid prototyping or other means of a filler material. Accurate resection has to be performed for the filler to fit, navigation is again required.

As the navigation now offers accurate guidance, the biggest factor of deviance is the means of resection. As the oscillating saw, as far as we know, cannot be accurately tracked by the CAS system, an alternative means of resection would be ideal in these types of operations. Adjustable saw blocks that are placed with the CAS system can be a possibility. A fully navigated means of resection would have the preference.

References

[1] Wong KC, Kumta SM, Chiu KH, et al.: Precision tumour resection and reconstruction using image-guided computer navigation. J Bone Joint Surg Br 2007;89:943-947.

[2] Deijkers RL, Bloem RM, Hogendoorn PC, et al.: Hemicortical allograft reconstruction after resection of low-grade malignant bone tumours. J Bone Joint Surg Br 2002;84:1009-1014.