Comparative study between conventional and computer-assisted preoperative 3D planning methods for bone sarcoma resection

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Background

Nowadays, the field of oncologic margin measurements does not have a defined application standard. Surgeons handle standard tools in order to define the tumor extension and then plan surgeries using bi-dimensional images from magnetic resonance and tomography.

Within the purview of computer-assisted surgery there are tools for planning and executing using 3D technology[1].

There is little literature available about both comparative studies between 2D and 3D planning methods[2] in bones and comparison between 2D and 3D tools for resecting sarcomas.

Proposes

The aim of this study is to reach ideal "in vitro" conditions with an experimental design. This experimental platform allows physicians to evaluate three different forms of carrying out a preoperative planning for tumor resection and then execute it using plastic bones.

Inclusive criteria:

· 2D digital images planning and execution without navigation

· 3D simulation scenario planning and execution without navigation

· 3D simulation scenario planning and execution with navigation

Three physicians specialized in bone tumors unfamiliar with computer-assisted techniques have been evaluated so as to determine the degree of accuracy of each method and the impact of inaccuracy in oncologic margin bone sarcoma resection.

Methods

Plastic bones were used for the experiment (Synbone): a proximal femur, a distal femur, a pelvis and a humerus. These plastic bones were scanned in a multitrack tomography (Toshiba Aquilion).

Images acquired in 2D were used in order to perform 2D planning. Then the obtained images were processed to get a 3D simulation scenario containing each bone. Similar cases to a low degree chondrosarcoma were simulated, that is to say a small tumor without edema and with net limits in each bone. In this way, four problematic cases were depicted in four bones.

The three medical practitioners were evaluated according with each method used (see table 1). Execution of planning was performed with a Colibri saw (Synthes) and a saw blade of 1.2 mm thick. Timing for planning and executing were tested separately. Once carried out the cuts the plastic bones were sent to tomography and 3D reconstructed.

3D planned and navigated cases were compared with the original planning[3]. Technicians contrasted distances between the executed osteotomy and the closest spot to the tumor: the optimum oncologic margin[4].

Finally, the total volume of bone resection was measured and compared.

Results

The volume, planning time and execution time, and the minimum margin are shown for each surgeon and each method in Table 1. Surgeon A, when planning in 2D, left the tumor in the patient (minimum margin of 0mm). Surgeon B, when planning in 2D, left the tumor in the patient. Surgeon C (2nd year resident), when planning in 2D, left the tumor in the patient, and when using the rest of the methods she resected the tumor en bloc but violated the surgical margin of 5mm. Two examples of these results are shown in Figure 1, where it can be seen that the cutting saw entered the tumor.

Conclusion

The results have shown that, in all cases, the 2D planning derived in a wrong resection, leaving tumoral tissue inside the patient and in some cases spreading tumoral tissue when entering inside the tumor with the cutting saw. The 3D planning method improved the results, even in the most inexperienced surgeon (C) that achieved a resection en bloc with an unsafe margin. There is no apparent difference between 3D planned non-assisted resections and and 3d planned navigation-assisted resections with the available amount of data, even though these are the safest methods. There is also no apparent difference between experienced surgeons (A and B) and a resident (C) when planning with 2D tools.

To conclude, the proposed model is on its experimental stage. Nevertheless, the model allows physicians to compare and determine advantages and disadvantages of tools and methods used in oncologic surgeries. 3D planning and navigation are potential assets in order to acquire accuracy during procedures and to reach an optimum margin in tumor resections. Simulation scenarios and intraoperative navigation platforms provide a safer environment so as to perform computer-assisted surgeries, which are efficient tools for tumor resections.

Surgeon	Method	Bone	Volume (cm^3)	Planning Time (min)	Execution Time (min)	Minimum Margin (mm)
A	3D	Distal Femur	69.4	21	11	16.00
		Proximal Femur	31.1	15	16	8.97
	2D	Humerus	12.6	32	9	0.00
		Iliac Wing	21.2	18	9	0.00
	NAV	Acetabulum	15.1	13	46	7.20
B	NAV	Distal Femur	35.3	34	10	8.17
		Proximal Femur	35.3	12	57	10.58
	3D	Humerus	20.9	26	10	6.10
		Iliac Wing	14.2	24	8	8.00
	2D	Acetabulum	11.6	15	22	0.00
C	3D	Distal Femur	18.1	27	30	0.83
		Proximal Femur	17.1	8	5	4.00
	2D	Humerus	5.4	50	33	0.00
		Iliac Wing	8.2	11	15	0.00
	NAV	Acetabulum	12.5	10	25	4.00

Table 1: This table shows for each surgeon participating in the experiment the used method (2D: bidimensional planning, 3D: tridimensional planning, NAV: tridimensional planning and navigation-assisted execution), the bone and region where the simulated tumor was located, the volume resected, the time used for planning and for executing the resection and the minimum margin. The grey margins are below the 5mm minimum safe margin. In the cases where the minimum margin is 0mm, the tumor was cut or it was directly not resected.

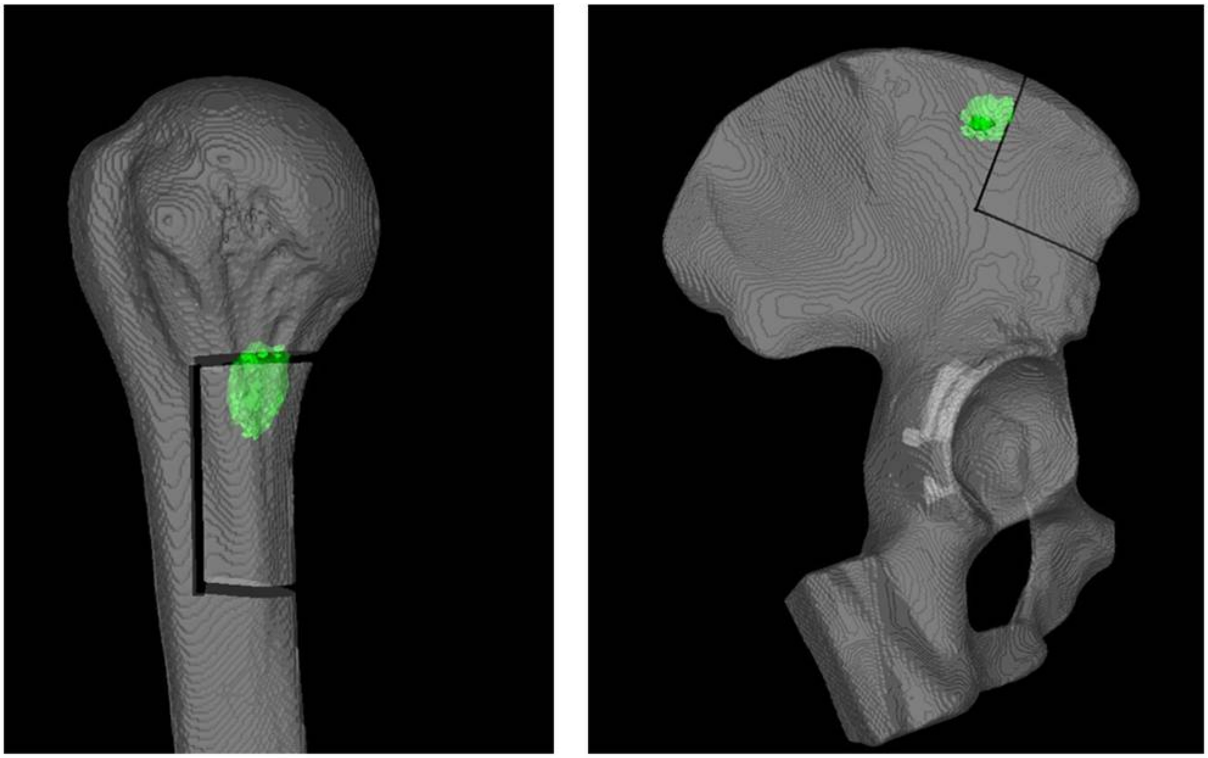

Figure 1: Common mistakes when planning using bidimensional (2D) images. In both cases the cutting saw entered the tumor.

References

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