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Research paper

Patient comprehension of oncologic surgical procedures using 3D printed surgical planning prototypes

A. Tejo-Otero[a,#], A. Valls-Esteve[b,c,#,*], F. Fenollosa-Artés[a,h], A. Siles-Hinojosa[d], B. Nafria[g], M. Ayats[b,c], I. Buj-Corral[h], MC. Otero[i], J. Rubio-Palau[e,c], J. Munuera[f,c], L. Krauel[d,c]

[a] *Centre CIM, Universitat Politècnica de Catalunya (CIM UPC), Carrer de Llorens i Artigas, 12, 08028, Barcelona, Spain*
[b] *Innovation Department. Hospital Sant Joan de Déu, Universitat de Barcelona, Santa Rosa 39-57, 08950 Esplugues de Llobregat, Spain*
[c] *3D Unit (3D4H), Hospital Sant Joan de Déu, Universitat de Barcelona, Spain*
[d] *Department of Pediatric Surgery, Hospital Sant Joan de Déu, Universitat de Barcelona, Spain*
[e] *Maxillofacial Unit, Department of Pediatric Surgery, Hospital Sant Joan de Déu, Universitat de Barcelona, Spain*
[f] *Department of Diagnostic Imaging, Hospital Sant Joan de Déu, Universitat de Barcelona, Spain*
[g] *KIDS Barcelona, Sant Joan de Déu Research Foundation, Barcelona, Spain*
[h] *Universitat Politècnica de Catalunya. Department of Mechanical Engineering. School of Engineering of Barcelona (ETSEIB). Av. Diagonal, 647. 08028, Barcelona, Spain*
[i] *University of the Basque Country (UPV/EHU). Department of Computer Languages and Systems. School of Engineering of Vitoria-Gasteiz. Nieves Cano 12, 01006, Vitoria-Gasteiz, Spain*

A R T I C L E   I N F O

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A B S T R A C T

Purpose: Patient understanding of complex surgical procedures and post-intervention consequences is often poor. Little is known about the effectiveness of 3D printed models to improve the comprehension of the medical information provided to patients. The purpose of this study was to determine if 3D printed patient-specific anatomical models could help improve patients' satisfaction and understanding of complex oncological surgical procedures, their risks, benefits, and alternatives.
Basic procedure: A randomized, controlled crossover experiment was performed, where subjects were randomly assigned to different treatments of the study. This experiment involved teenage patients experts from Kids Barcelona, a Young Person's Advisory Group. The team (n = 14, age range 14–20, 9 females and 5 males) was divided into two groups involved in two simulated pre-surgical outpatient visits for complex oncologic surgical procedures: a high-risk stage 4 abdominal neuroblastoma, and a biliary tract rhabdomyosarcoma. Two senior oncologic surgeons participated in the study by performing the structured outpatient pre-surgical visit. Each participant received information before the study explaining the study methodology and was given a questionnaire.
Main findings: Data analysis of the group using the 3D printed model for the neuroblastoma case showed better results than without the 3D model. On the other hand, conversely, on the data analysis of the rhabdomyosarcoma case with the 3D printed model no better results were observed as compared to the case of not using a 3D model. However, the results of the participants' knowledge were still better than before the intervention. Satisfaction was significantly better with a 3D model in both cases.
Conclusion: The use of 3D physical models improves the patient's knowledge and shows the effectiveness of 3D printed models to enhance the comprehension of the medical information provided to patients and improve satisfaction.

1. Introduction

The development of additive manufacturing (AM) technologies during the last years has led to the use of this technology in different fields: aeronautics, architecture, medicine, and many other fields. AM is used in medicine for many different purposes such as bioprinting [1], scaffolds [2], surgical planning anatomical models [3–5], surgical tools, and education among others. The 3D printed surgical planning anatomical models have been mainly used for preoperative surgical planning to assess the feasibility of the procedure, surgical approach, potential complications, and surgical training [6]. Additionally, they have been used in the education of both patients and residents or undergraduate medical students.

* Corresponding author.
E-mail addresses: atejo@cimupc.org (A. Tejo-Otero), avallse@sjdhospitalbarcelona.org (A. Valls-Esteve).
# Equal contribution to this paper.

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Preoperative clinical visits are a particularly important aspect of the surgical process. Patients and their families must properly understand their condition, the potential treatments and their consequences, the course of recovery, and accurate comprehension of the risks and benefits of the planned procedures. This information also affects the decision-making and consent process. However, this is not always accomplished. With current methods, little is known about patient comprehension and health literacy of adolescents and young adults (AYAs) and their families [7]. Traditionally, patient education is performed verbally or using written material by the referring clinician. Often, support materials such as the computed tomography (CT) scan or magnetic resonance imaging (MRI) with its digital imaging and communications in medicine (DICOM) images format are shown to the patient. However, information comprehension and retention are usually poor [8,9]. Alternatives exist by using 3D printed prototypes of the patient-specific anatomy [11–20]. 3D models offer the possibility of using the sense of sight and touch together [3–5]. 3D printed models could help pediatric patients understand their condition. In addition, parents can also understand the nature of the disease and treatment options for their kids. For example, Silberstein et al.[16] manufactured, using stereolithography (SLA), five high-fidelity, patient customized, 3D physical models of renal units with renal lesions. Patients were able to see and manipulate them. They stated that the models enhanced their comprehension of the renal tumor.

In another example, adolescent patients who suffer from congenital heart disease (CHD) completed some questionnaires using both 3D healthy and pathological heart models. These prototypes were manufactured using selective laser sintering (SLS), a type of powder bed fusion (PBF) AM technology [17]. A vast majority of the participants agreed that these models were useful and fun, and an excellent tool for improving the visit to the doctor.

Regarding undergraduate education and residency training, one of the main advantages of using these 3D physical models is that they do not require dead human bodies that are scarce in some medical schools [21–25]. Another advantage is the capacity of reproducing any anatomy, even those rare clinical cases that some surgeons may only see once in their careers. For instance, a randomized study revealed that the 3D printed model markedly improved the identification of a complex spinal fracture by medical students and was equally appreciated by all participants and comprehended by both sexes. These 3D realistic models were manufactured using material extrusion, another AM technology. Within this category, FFF (fused filament fabrication) was the specific technique applied [26–29].

Amongst all these studies, a wide range of AM technologies have been used: SLS and FFF are the most used, but also material jetting, binder jetting, and vat photopolymerization. All these studies focused on just one specific organ, for instance, the liver or heart, but they do not include other anatomical relations.

In the present study, two different oncologic 3D models have been used for surgical education: a high-risk stage 4 abdominal neuroblastoma and a biliary tract rhabdomyosarcoma. The purpose of this study was to determine if 3D printed patient-specific anatomical models could help improve patients' understanding of complex oncological surgical procedures, their risks, benefits, and alternatives.

2. Materials and methods

2.1. Patients

An experimental study with a predefined group with random assignment of patients to each arm of the study (control and study groups) was performed at a referral pediatric university hospital (see Fig. 1). This study involved adolescent patients (n = 14, age range 14–20, 9 females and 5 males) and two senior pediatric oncologic surgeons. Adolescent participants received an informal survey before the study, which explained the study methodology. They were divided into two groups (one for the neuroblastoma and the other for the rhabdomyosarcoma) of seven members balanced by sex and age. Each participant went through two simulated outpatient pre-surgical visits for a complex oncologic surgical procedure: a high-risk stage 4 abdominal neuroblastoma and a biliary tract rhabdomyosarcoma. One group (group #2) had the neuroblastoma visit explained by a senior oncologic surgeon with a 3D model and the second visit regarding the rhabdomyosarcoma case explained by another senior pediatric oncologic surgeon without the 3D model. The other group (group #1) had the 3D model for the rhabdomyosarcoma and no 3D model for the neuroblastoma visit case (second visit). Two oncologic surgeons conducted the face-to-face visits by previously agreeing on the structure and content of the session to ensure that there were no significant differences between groups. In addition, to further correct the potential bias introduced by the surgical factor, the 2 groups were crossed for the simulated second visit (see Fig. 1). Written consent was obtained before administering the survey from all individual participants included in the study.

2.2. Setting and assessment tool

This study involves the completion of different questionnaires (see Tables 5 and 6) done by medical specialists in pediatric oncology. First, the participants needed to fill in a 24 questions knowledge assessment questionnaire consisting of three sections: general knowledge of the anatomy involved, general knowledge of the disease, and finally general knowledge of the surgical procedure. After completion, participants had a face-to-face pre-operative simulated visit with the surgeons (Dr. Krauel and Dr. Siles-Hinojosa) for each of the two intervention procedures. Each doctor explained one procedure, either the neuroblastoma or the rhabdomyosarcoma.

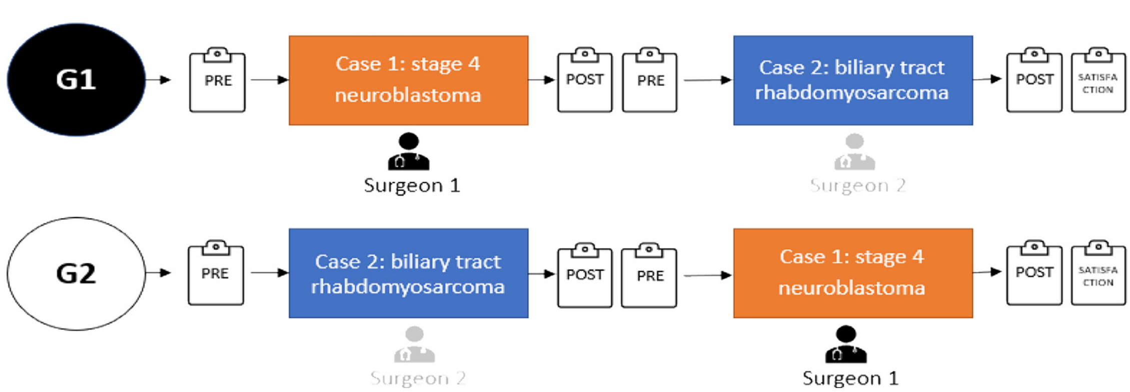

Fig. 1. Process of the interventions.

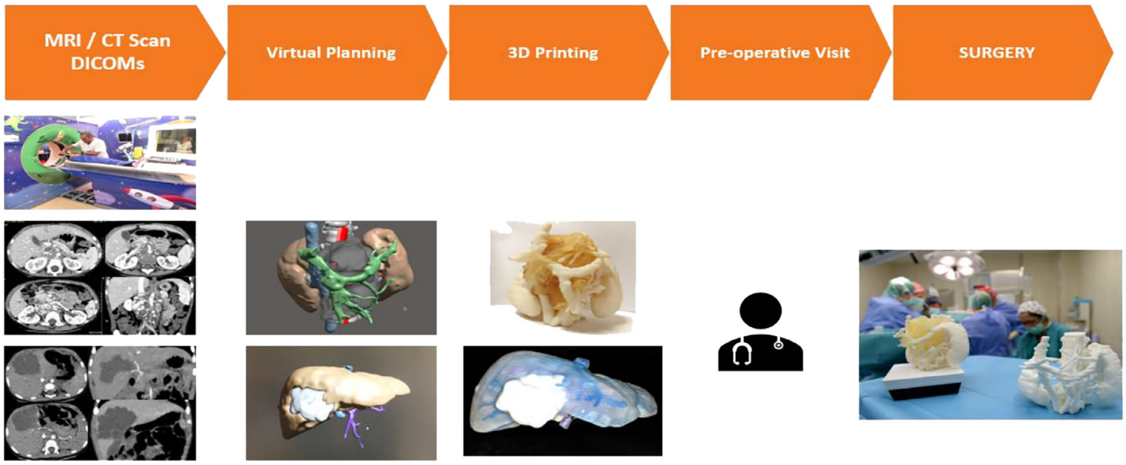

Fig. 2. Manufacturing 3D highly realistic models.

Depending on the participant, the 3D model was used or not. Each participant had one case explained following the structured classical visit with verbal information discussed with CT scan DICOM images as a support tool. The other case used a 3D model to help the explanation. After each visit, another questionnaire was filled out. This questionnaire had 30 questions, adding to the former 6 questions more about potential risks and benefits of the procedure. Finally, after the two visits and fulfilling all questionnaires, patients were asked to do a satisfaction survey with 10 questions on a Likert scale. All participants were able to recreate real medical appointments.

The questionnaire was completed on paper. Knowledge assessment questionnaires were developed by senior oncological surgeons, based on preoperative visits experience, "must knowns" for the patient (anatomy, procedure, risks and benefits, and potential consequences), and frequently asked patients' questions. A "true-false-not sure" format was chosen to facilitate participants' completion.

The questionnaires were scored based on the number of correct answers, considering incorrect both "incorrect" answers and "not sure". The satisfactory survey was scored following the 1 (strongly disagree) to 10 (strongly agree) Likert scaling (see Table 7).

2.3. 3D models

The process of manufacturing the 3D printed models can be seen in Fig. 2. Both 3D models were manufactured using different technologies. The 3D images were acquired by combining an iodinated contrast-enhanced abdominal CT scanner (iCT 256-row Philips) and abdominal MRI (Ingenia 3T Philips). Those studies were performed at SJD Barcelona Children's Hospital (Barcelona, Spain) and saved in DICOM format. Post-process for image segmentation is done using a semiautomatic segmentation and corrected manually using IntelliSpace Portal software (Philips). A commercially available software. Other options are available in the market: commercial options (Mimics); or open-source (3D Slicer). The segmentation process took around 3 h per case under the supervision of an experienced radiologist. The anatomical structures and tumors are challenging to segment and differentiate from surrounding unwanted structures. 3D printing processes were then performed at CIM UPC (Barcelona, Spain). The 3D printing manufacturing of the anatomical models has some differences between the two models.

The high-risk stage 4 neuroblastoma 3D model was manufactured using a Connex 500 machine by Stratasys (material jetting technology) (see Fig. 3). Differently, the biliary tract rhabdomyosarcoma was manufactured using the molding technique. First, the outer mold was manufactured using a polylactic acid (PLA) filament in FFF. The 3D printer used was a Sigma model from BCN3D Technologies (Barcelona, Spain). Then, the inner embedded parts were manufactured using polyamide (PA) 12 in SLS. The 3D printer used was a Ricoh AM S5500P (Japan). The inner parts were colored and placed inside the mold. Both outer molds were joined and fixed with clamps for a few hours applying pressure to achieve a good attachment between both halves of the mold for casting. Finally, the silicone (ESSIL 291 Resin), and the catalyst (ESSIL 292 Catalyser), both supplied by Axson Technologies, were mixed at a volume ratio of 10:1. When they were fully mixed, the mix was cast into the mold. 24 h after casting, the molds were separated, and the surgical planning prototype was obtained (see Fig. 4).

2.4. Data analysis

To carry out this experimental study, a repeated measure crossed design was applied. The differences between the participants, before and after the simulated medical appointment, and with the 3D model were studied. Group #1 (ie, 3D model) was compared to Group #2 (ie, no 3D model) in rhabdomyosarcoma (see Table 1). And in the neuroblastoma, Group #1 (ie, no 3D model) was compared to Group #2 (ie, 3D model).

Based on the design, the research hypotheses in Table 2 were planned. The response variable was the percentage of correct answers for each question in the pretest and posttest. For example, H_{02} stated: "In the case of neuroblastoma, there are differences between using or not the 3D printed model in the percentage of correct answers."

Results were summarized: mean ± standard deviation and analyzed with SPSS v 26.0. Statistical difference intra-groups were assessed using the Student's t-test for paired samples for those groups satisfying assumptions of normal distribution (assessed using Shapiro–Wilk normality test, n<50). As they are intra-groups, it is not necessary to evaluate variance homogeneity. For groups without normal distribution but variance homogeneity, a Wilcoxon signed-rank test was applied. A p-value < 0.05 was considered statistically significant.

3. Results

3.1. General knowledge pre vs post comparative

A total of 14 teenagers completed a questionnaire about the use of the 3D printed surgical planning prototypes (see Supplementary figures - Figure 9). On the pre-visit questionnaires, the mean knowledge score was 38.98% for the first case ((26.1;51.87) 95% confidence interval) and 39.58% ((28.76;50.40) 95% confidence interval) for the second case. General knowledge of the anatomy involved: 45.53% for

Fig. 3. Neuroblastoma prototype.

the first case and 51.78% for the second, general knowledge of the disease was: 35.71% and 33.04%. Finally, general knowledge of the surgical procedure showed 35.71% for the rhabdomyosarcoma and 33.92% for the neuroblastoma.

After the simulated visit, the mean knowledge score increased significantly, being 86.31% ((79.42;93.2) 95% confidence interval) for the rhabdomyosarcoma case and 76.48% ((66.60;86.37) 95% confidence interval) for the neuroblastoma case. More in-depth, general

Fig. 4. Biliary tract rhabdomyosarcoma prototype.

Table 1
Experimental design.

	Session 1 Pretest-Postest (3D/No 3D)		Session 2 Pretest-Postest (3D/No 3D)	
	No 3D Model	3D Model	No 3D Model	3D Model
Rhabdomyosarcoma		Group #2		Group #1
Neuroblastoma	Group #1		Group #2	

Table 2
Hypotheses (RMS: rhabdomyosarcoma, NB: neuroblastoma).

	PRE		POST			
	RMS	NB	RMS		NB	
			Without 3D Model	3D Model	Without 3D Model	3D Model
H01	√		√			
H02	√			√		
H03		√			√	
H04		√				√
H05			√	√		
H06					√	√

knowledge of the anatomy involved: 81.25% for the first and 72.32% for the second, general knowledge of the disease: 86.61% and 73.21%, and, finally, general knowledge of the surgical procedure: 91.07% for the first and 83.93% for the second case.

3.2. General knowledge post comparative with 3D model

The hypotheses H_{01} and H_{02} in Table 3 were analyzed. For both cases, there are no significant differences between the groups without a 3D model and with 3D (for Rhabdomyosarcoma, $p = 0.133$; for Neuroblastoma, $p = 0.090$).

3.2.1. Neuroblastoma

The data analysis using the 3D printed model for the neuroblastoma case showed better results than without the 3D model. The use of the 3D printed model of the neuroblastoma tumor helps to understand its general knowledge in all 4 aspects (anatomy, disease, surgical procedure, and risks), as shown in Fig. 5.

As seen in Figure 10 (supplementary data), a more specific data analysis was done by focusing on the results achieved question by question. The knowledge of the patient in the neuroblastoma case was improved after the appointment with the surgeon. Additionally, this improvement was better if the 3D printed models was used.

3.2.2. Rhabdomyosarcoma

The results of the data analysis of the rhabdomyosarcoma differ from that of the neuroblastoma, as in this case with the use of the 3D printed model no better results were seen. The use of the 3D printed model in the rhabdomyosarcoma tumor helps to understand the surgical procedure, but not the rest of the categories, as shown in Fig. 6.

As seen in Figure 11 (supplementary data), a more specific data analysis was done by focusing on the results achieved question by question. It is interesting to see the improvement in the knowledge in the questions related to the surgical procedure. This might be because understanding the surgical procedure implies understanding several concepts at the same time (anatomical relationships, tumor position, and surgical approach). To understand these concepts is crucial to be aware of the potential risks and benefits of a procedure and the results seem to show that the use of the 3D model helps to understand it better.

Table 3
General Knowledge POST Comparative with and without 3D Model.

		Mean	SD	Significance
H_{01}	G1_Rhabdomyosarcoma_No3D	85.2381	24.73884	0.093
	G2_Rhabdomyosarcoma_3D	77.6190	25.63297	
H_{02}	G1_Neuroblastoma_3D	79.0476	24.23592	0.091
	G2_Neuroblastoma_No3D	73.3333	25.64669	

3.3. General knowledge pre vs post comparative with and without 3D model

To evaluate the hypotheses H_{03}, H_{04}, $H_{05,}$ and $H_{06,}$ two analyses were performed comparing the results of the first three knowledge categories (General knowledge of the organ, General knowledge of the disease, and surgical process). First, a pre vs post-analysis comparing the 3 categories without a 3D model and a second pre vs post-analysis with a 3D model. In all cases, the 4 hypotheses have been rejected. There are significant differences in the 4 pairs (p <0.05) between the pre and the post, regardless of whether a 3D printed model is used to explain the tumor (see Table 4).

Fig. 7 represents the boxplots of the values PRE vs POST for each type of tumor, with and without a 3D model, and concerning the three categories of general knowledge (anatomy, disease, and surgical procedure).

3.4. Satisfaction

The overall satisfaction of the patients was 9.41 ± 0.77 which indicated that the patients are satisfied with the 3D model enhanced appointment. Question number 8 shows that the surgeon's explanation using a 3D printed surgical planning prototype was more liked than without the use of 3D realistic models (see Fig. 8).

4. Discussion

Surgical oncological procedures are complex, and, in some cases, their treatment, risks, and benefits are difficult to understand by patients [30]. AYA patients and their families must understand the anatomy and its relations to the organs affected by the tumor. Cancer patients with poor health literacy may have misconceptions about their disease and ineffective communication with their health professionals, leading to unnecessary interventions, greater anxiety, poor adherence to their treatment plans, and dissatisfaction [31,32]. The

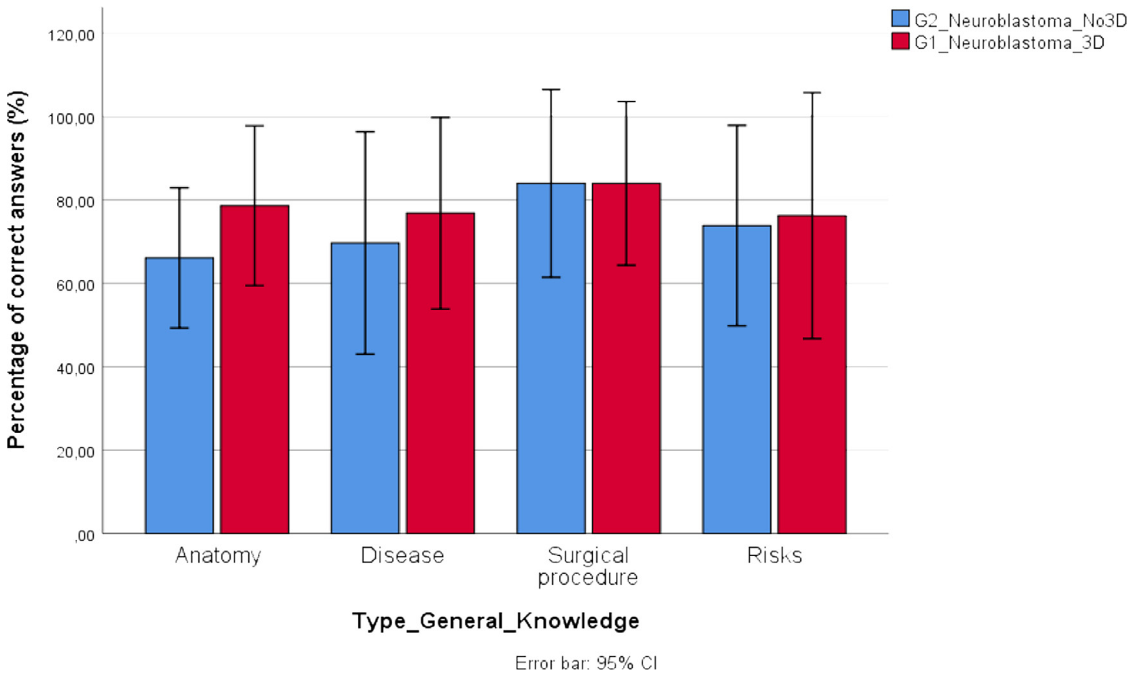

Fig. 5. Differences in the number of correct answers in the neuroblastoma case. The use of the 3D models shows to have a positive impact on the understanding of the patients. Blue bar corresponds to no use of 3D model, while red bar to the use of 3D model.

3-dimensional perception of the location and organs involved by the tumor to vessels and organs is key and not always easy to figure out. Before 3D printing started to be used in the medical field, patient consultations were carried out using DICOM images to accompany the surgeons' verbal explanations of the procedure, as well as its potential complications. This is still the most common way to communicate such information worldwide [33]. However, 3D models can give a more accurate understanding of what is happening, why surgery is necessary, how is going to be performed, and what are the risks and benefits of the procedure. Furthermore, it is difficult for clinicians to convey the message to each patient's health literacy [29]. When Additive Manufacturing (AM) started to be used for surgical planning, patients began to acquire a greater knowledge of the real situation of the disease they suffer from. This improvement came hand in hand with a decrease in production costs for the 3D anatomical models, which made 3D planning more accessible and used for surgical planning of pediatric tumors [34]. Therefore, two different models were used in this study to verify the effectiveness of 3D printed surgical planning prototypes in the practice setting and the improvement of patient comprehension. As far as is known to the authors' knowledge, no study has been conducted comparing two different oncologic interventions with 3D models at the same time, nor the use of 3D

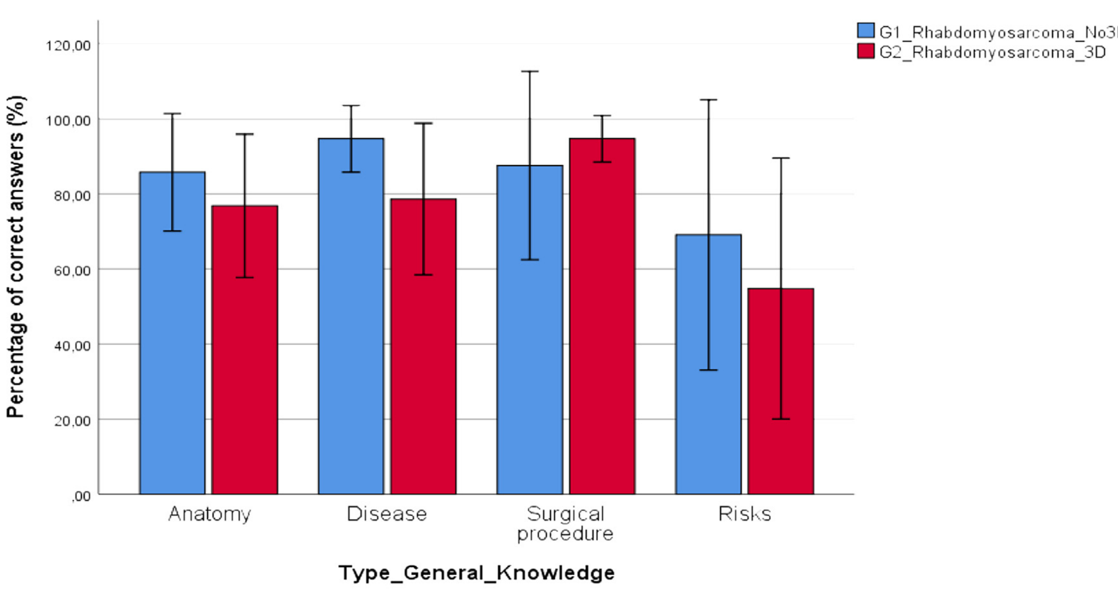

Fig. 6. Differences in the number of correct answers in the rhabdomyosarcoma case. Blue bar corresponds to no use of 3D model, while red bar to the use of 3D model.

Table 4
General Knowledge PRE VS POST Comparative with and without 3D Model.

		Mean	SD	Significance
H_{03}	Pre_Rhabdomyosarcoma	38.9881	30.52187	0.004
	G1_Rhabdomyosarcoma_No3D	89.2857	20.74478	
H_{04}	Pre_Rhabdomyosarcoma	38.9881	30.52187	0.000
	G2_Rhabdomyosarcoma_3D	83.3333	20.49376	
H_{05}	Pre_Neuroblastoma	39.5833	25.62261	0.010
	G2_Neuroblastoma_No3D	73.2143	26.74687	
H_{06}	Pre_Neuroblastoma	39.5833	25.62261	0.005
	G1_Neuroblastoma_3D	79.7619	23.79917	

models for patient comprehension in pediatric and AYAs abdominal oncology.

Overall, the explanation of the surgeons can be enough in most cases. In Fig. 5, with a full explanation of the disease, it is shown that patients could acquire not only the basics but also some deeper concepts. Nonetheless, in complicated procedures, it is particularly useful the use of a 3D printed model to fully understand all the details of the disease, and the communication between patient and surgeon is improved. That was the case in the neuroblastoma tumor in our study. For instance, by using 3D realistic models, patients and their

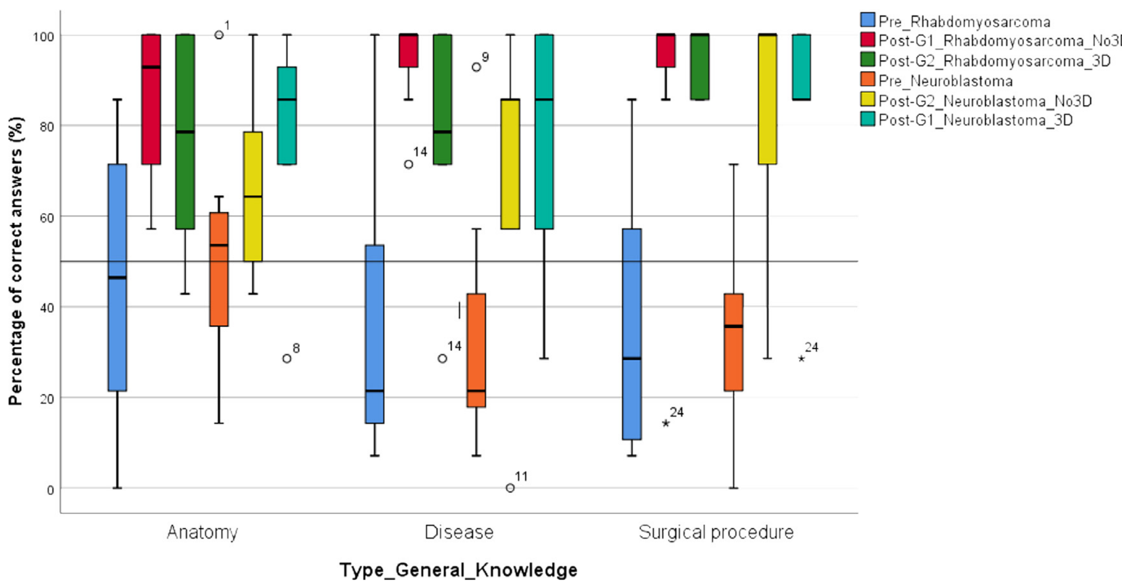

Fig. 7. General Knowledge PRE VS POST Comparative with and without 3D Model. Blue and orange colours correspond to the knowledge of the diseases before the appointment. On the one hand, red color corresponds to the knowledge acquired after the appointment using no rhabdomyosarcoma 3D model, while the green color shows the results with the use of 3D model. On the other hand, the yellow color is for results obtained after the appointment by not using the neuroblastoma 3D model, and the 'light' green with 3D model.

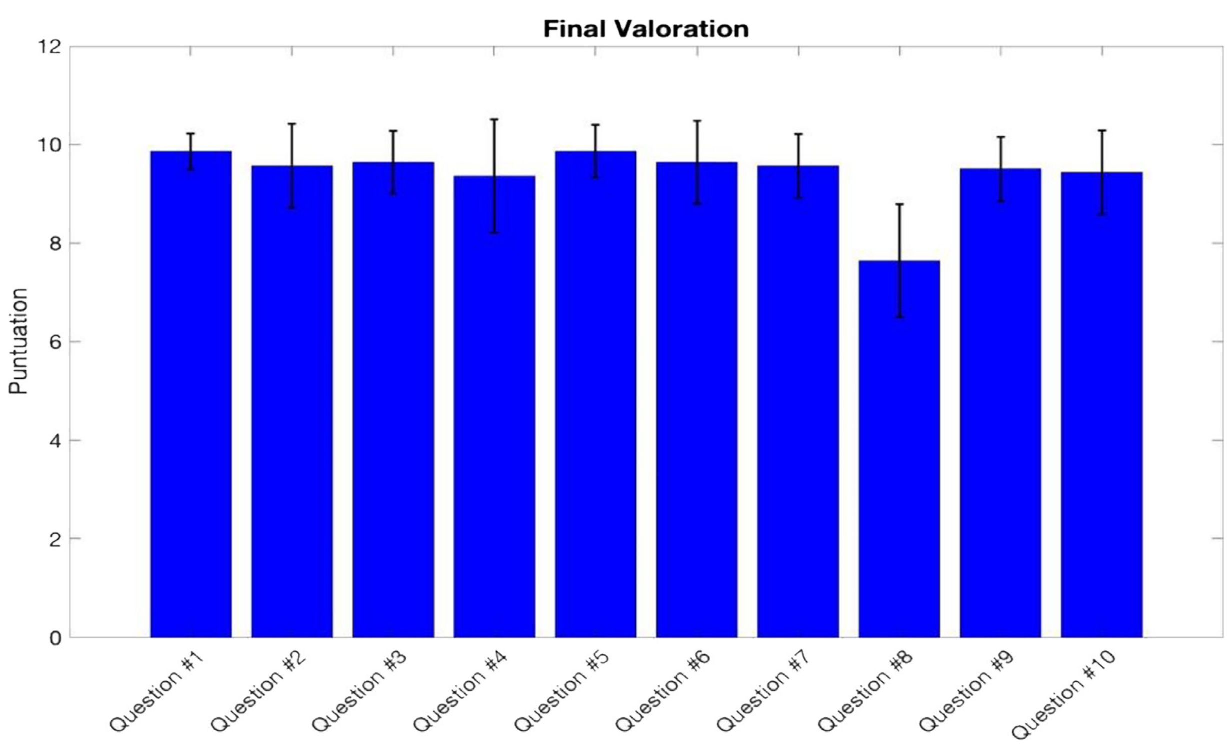

Fig. 8. Final assessment of the patients.

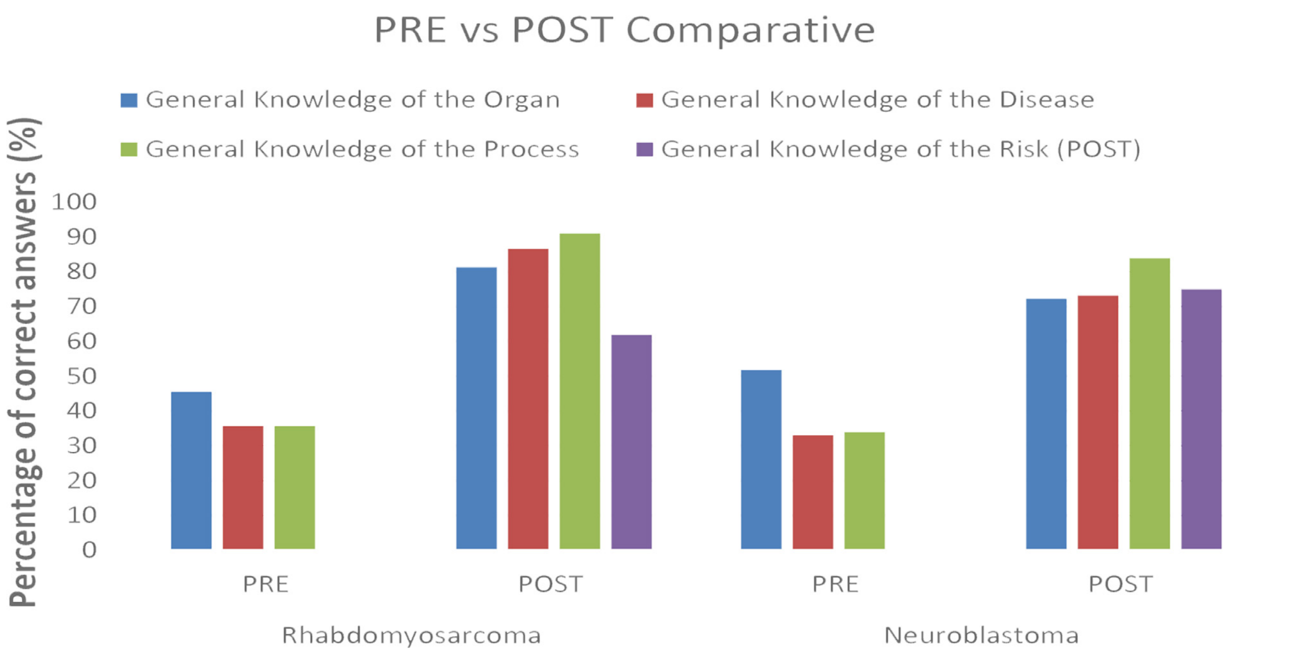

Fig. 9. General Knowledge PRE Vs POST Comparative.

families can see the size of the tumor and its relation to vessels and other organs and easily understand the procedure.

On the one hand, regarding abdominal neuroblastoma, the 3D printed model improved the knowledge in the four knowledge categories evaluated, and it was demonstrated to be useful for enhancing patient understanding of treatment and disease. This is also described in other published works, demonstrating the improvement 3D models have in anatomical comprehension [35], in surgical procedure and enhanced patient-surgeon communication [36], and patient satisfaction [37].

Regarding the rhabdomyosarcoma case, comprehension was only found to be more effective with a 3D model for the understanding of the surgical procedure. Despite that, a significant improvement of the patient knowledge with the 3D model as compared to the results achieved before the appointment was found. The difference in the impact of using the 3D model in the cases of neuroblastoma and the rhabdomyosarcoma might be related to the difference in complexity of each procedure. The hepatectomy needed in the rhabdomyosarcoma is known to be, in general, a less complex procedure than the resection of neuroblastoma, thus, easier to explain and understand without the aid of 3D models.

Even though the 3D rhabdomyosarcoma model for the pre-surgery visit explanation was not as effective as initially thought, in all cases, patients' satisfaction in the visits with the 3D model was rated as excellent. The average was 9.41 (21.1% more than without the model), showing that patients think 3D models help enhance surgery comprehension and facilitate patient-doctor communication. This can be compared with Bernhard et al.[14], in which the overall satisfaction was 9.4, which is close to our results. It can be stated then that 3D printed surgical planning prototypes are useful tools for patient education, especially for complex procedures.

Despite all the advantages of 3D printed surgical planning prototypes, there are still challenges to fully adopting these techniques in surgical planning. One of its major drawbacks is the financial costs of patient-specific 3D printed models. Our models cost about $2000 for neuroblastoma and $500 for the biliary tract rhabdomyosarcoma as previously described in [4] and similar to [38]. They are high-quality and detailed 3D printed models that are mainly used for surgeons' rehearsal experience. Regarding patient education, less expensive 3D prototypes could be manufactured with still enough quality and user-friendly as mentioned by Watson [23] and Witowski, J.S [39].

Alternatives to 3D models exist for the training and education of both patients and medical students and have been described in the literature. Augmented and virtual reality (AR and VR) could be another outcome of the segmented 3D model, presenting several advantages over 3D printing that have the limitation of the cost of each printed model, its limited use by one person at a time, and the restricted capacity of simulating operation on it only once. For instance, Vivek et al.[40] proved the usefulness of VR as a learning and comprehension tool for patients with complex vascular disease (abdominal aortic aneurysm). Shannen et al. [41], found similar results in cancer patients after a scoping literature review[41], although the need for a VR headset per patient was identified as a potential challenge. Wake, N. et al.[42], evaluated the impact of using 3D printed models, 3D virtual models in a 2D computer monitor, and AR as compared to classical DICOM imaging in surgeons' sessions for patients with renal and prostate cancer. With a sample of 200 adult patients, a significant majority had a greater understanding of using 3D printed models versus imaging for all measures including comprehension of disease, cancer size, cancer location, treatment plan, and the comfort level regarding the treatment plan. Of the three advanced imaging methods, 3D printed models were the most helpful to patients, especially in understanding the anatomy, disease, tumor characteristics, and surgical procedure [42].

Strengths and limitations of the study

Limitations of the study include the small number of test participants (n = 14), which did not allow to prove all hypotheses in a statistically significant way. Strengths of this experimental study include the prospective design of the questionnaire, as well as the random sampling and crossed grouping of participants. Also, the focus on AYA patients and their families; being an understudied population with few published works. Moreover, all patients were seen at the preoperative simulated visit by the

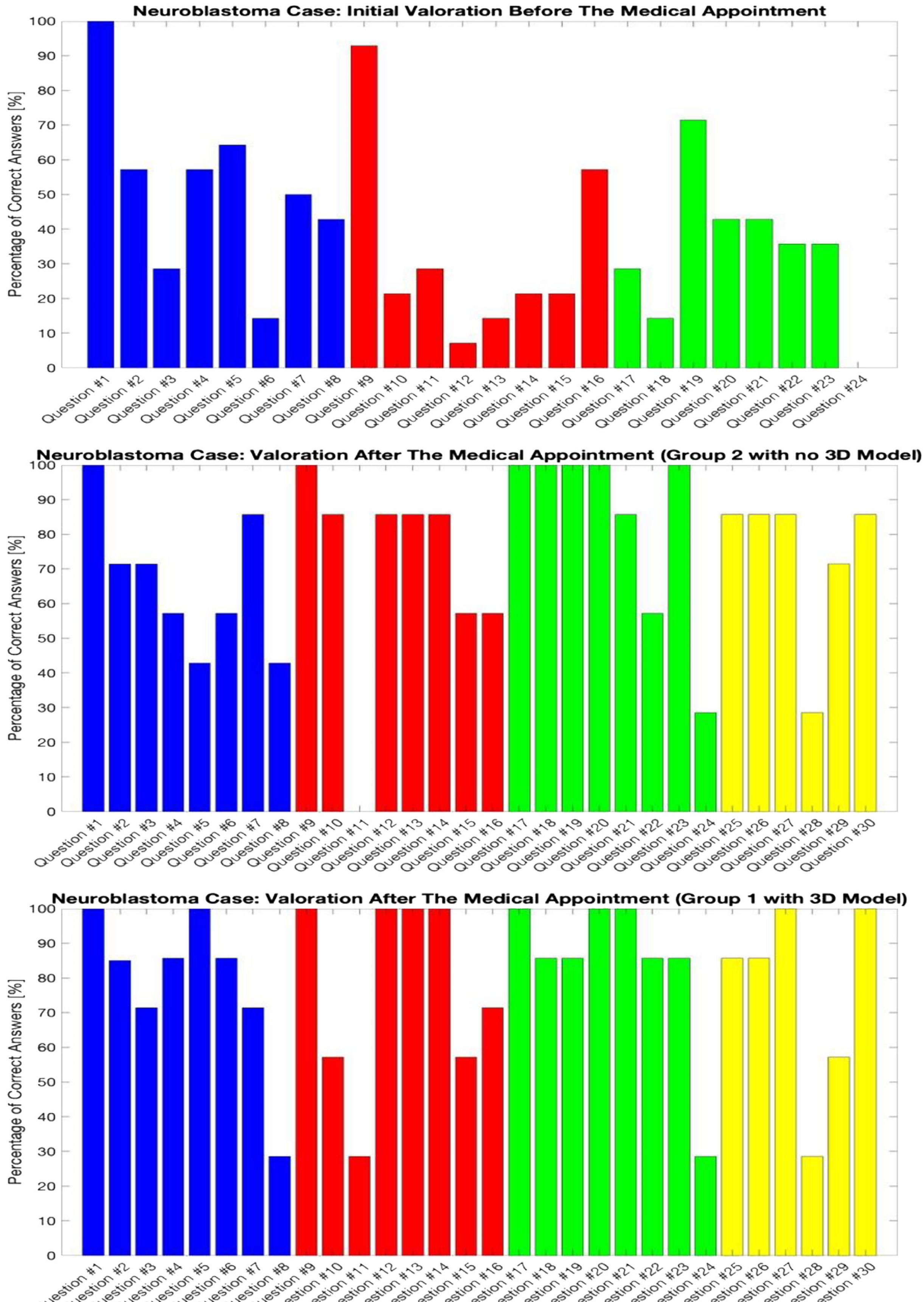

Fig. 10. Analysis of the neuroblastoma. Blue corresponds to anatomy; red corresponds to disease; green corresponds to surgical procedure, and yellow.

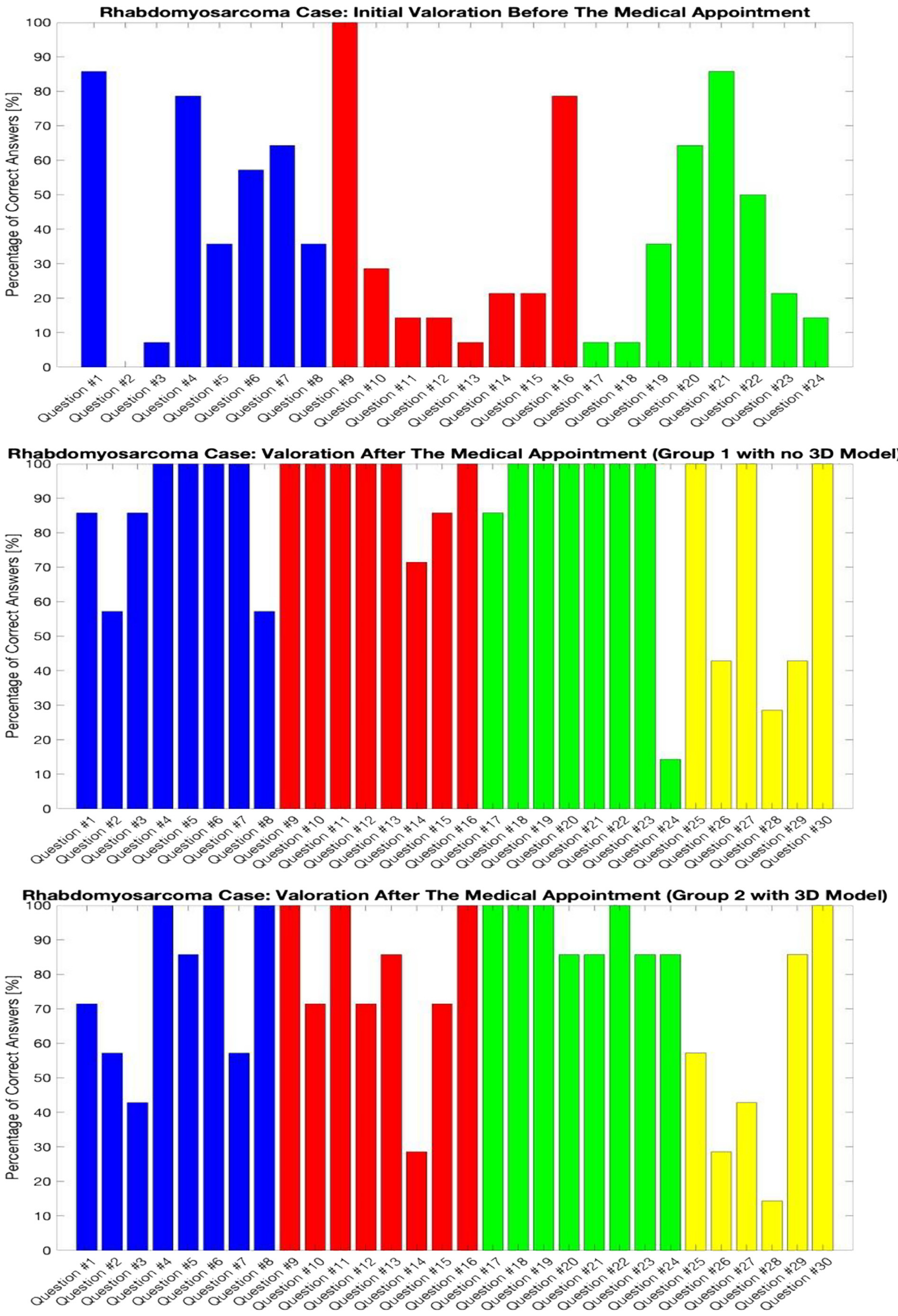

Fig. 11. Analysis of the rhabdomyosarcoma. Blue corresponds to anatomy; red corresponds to disease; green corresponds to surgical procedure, and yellow corresponds to risks.

same two surgeons, who provided a similar structured and educational experience.

5. Conclusion

3D printed patient-specific anatomical models showed to be useful for the improvement of the comprehension of complex oncological surgical procedures, their risks, benefits, and alternatives. Anatomy and the course of the disease were two of the main learning improvements using the 3D model in a pre-surgical visit with the patient.

Patient satisfaction in pre-surgical surgeon-patient visits can be substantially enhanced using patient-specific 3D printed anatomical models.

More studies should be done with a larger cohort of patients. Studies comparing the use of 3D models for patient/family education, to other alternatives such as VR, AR, or 3D models on a tablet are also needed. Nevertheless, the results obtained are meaningful and confirm that the use of 3D patient-specific models can help simplify and improve the health literacy of AYA patients. Thus, these results demonstrate that the use of 3D models is feasible and could be generalized for pediatric oncologic pre-surgical visits or other specialties in complex procedures. The high cost of production of the 3D anatomical models is a major limitation.

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Ethical approval

All procedures performed in studies involving human participants were by the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Declaration of Competing Interest

The authors have no conflict of interest.

All the different ethical approval were obtained by the hospital and parents.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.stlm.2022.100068.

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