

3D MODEL FOR CHEST WALL RECONSTRUCTION – UTILITY SURVEY

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Abstract

Introduction: Three-dimensional (3D) models contributed to many improvements in surgical planning, presenting irrefutable advantages in many fields and may play a relevant role in chest wall surgeries. This study aims to evaluate their usefulness for chest wall reconstruction surgeries.

Materials and Methods: All thoracic surgeons and residents practicing in the Iberian Peninsula and Latin America were asked to complete an online survey questionnaire, distributed through their respective national scientific societies. Results were analyzed using descriptive statistics and Mann–Whitney U test to access differences among surgeons with experience with 3D models and those without experience.

Results: A total of 145 answers were gathered from 15 countries. Most respondents had never performed thoracic wall reconstruction surgeries using rigid prosthesis with 3D patient-specific modeling. Most consensus was obtained regarding the positive contribution of a 3D model for preoperative communication with the patient, improvement in preoperative planning, and its positive role in training of less experienced surgeons. A tendency for neutral opinion was observed regarding its impact in avoidance of perioperative complications. Regarding 3D printing of a physical model, 74.8% agreed or strongly agreed that it is advantageous in comparison with a digital model, and 72.8% agreed or strongly agreed that it is advantageous for all candidates considered for chest wall reconstruction with rigid prosthesis. Surgeons without experience with 3D models value significantly more than those with experience their contribution for a more precise preoperative planning ($p=0.036$), planning of surgery duration ($p=0.008$), and consider 3D printed models to be advantageous for all candidates to chest wall reconstruction surgery ($p=0.028$).

Conclusion: 3D patient-specific models are not accessible to most surgeons but the overall opinion on their usefulness is very positive. Printed models seem to be advantageous over digital ones, and beneficial for all patients undergoing chest wall reconstruction surgery.

Keywords: Chest wall; reconstruction; 3D; model; printed

INTRODUCTION

In the last decade, 3D models have been employed in a variety of applications such as decision-making, surgical planning, trainee education, and communication. These models can convey intricate and nuanced information about the 3D spatial relationship between structures that may not be well appreciated in conventional 2-dimensional imaging modalities. Improvements in the field of 3D printing have made it possible to obtain from pre-procedural imaging scans of patients a physical replica of the individuals' unique anatomy. The 2D volumetric data provided by Computed Tomography (CT), Magnetic Resonance Imaging (MRI) or echocardiography can be converted into patient-specific 3D models.⁽¹⁾ Its usefulness has increased due to technology simplification, which allowed for cost reduction.⁽²⁾ Unfortunately, 3D printing

still requires specific knowledge and has a high cost,⁽³⁾ yet presents several advantages, such as the reduction of blood loss, ionizing radiation,⁽⁴⁾ surgery duration⁽⁴⁾⁽⁵⁾ and improvement of surgical outcomes.⁽³⁾ In fact, 3D printed models have been used extensively in several fields, but their manufacture must be justified by the complexity of the case, such as complex vertebral deformities,⁽⁶⁾ craniofacial deformities,⁽⁷⁾ or in the field of cardiology.⁽¹⁾ In cardiology, 3D printed models have been used in medical education and surgical or interventional training of junior doctors.⁽⁸⁾⁽⁹⁾⁽¹⁰⁾ Patient-specific 3D printed models have also been used to aid in the doctor–patient communication and improve the process of informed consent.⁽¹¹⁾⁽¹⁾ Moreover, 3D modeling can also help in personalized and customized surgical reconstruction of complex defects in the craniofacial region with precision by manipulating tissues based on the preoperative assessment, planning the shape of metal and

Section 1 (Multiple choice questions)

- Gender
- Country
- Experience as a thoracic surgeon
- Experience with rigid prosthesis patient specific 3D modeling for chest wall reconstruction surgery

If the respondent had experience with rigid prosthesis patient specific 3D modeling for chest wall reconstruction surgery, he/she would be redirected to section 2. If not, he/she would be redirected to section 3.

Section 2

(Likert scales for assessment of the level of agreement with the following statements. 1 – strongly disagree; 10 – strongly agree).

- The 3D model (printed, digital, or a combination of both) contributed to a more accurate preoperative planning compared to relying solely on imaging exams.
- The 3D model (printed, digital, or a combination of both) contributed to a better communication/explanation of the surgical procedure to the patient.
- The 3D model (printed, digital, or a combination of both) contributed to a more accurate planning of the surgery duration.
- The custom-made rigid prosthesis matched exactly (or with minimal adjustments) the defect reproduced in the 3D model (printed, digital, or a combination of both).
- The intraoperative findings were exactly as reproduced by the 3D model (printed, digital, or a combination of both).
- The 3D model (printed, digital, or a combination of both) significantly reduced the surgery duration.
- The 3D model (printed, digital, or a combination of both) significantly reduced intraoperative bleeding.
- The 3D model (printed, digital, or a combination of both) helped prevent potential postoperative complications.
- The 3D model (printed, digital, or a combination of both) contributed positively to the training of less experienced surgeons.
- The material used in the 3D model printing was similar, in terms of rigidity, to the intraoperative findings.
- The printing of 3D models is advantageous for all patients undergoing chest wall reconstruction with the placement of a custom-made rigid prosthesis.
- Overall, printing a 3D model is more advantageous compared to a digital 3D model.

(Multiple choice question)

- Number of chest wall reconstruction surgeries performed using a custom-made rigid prosthesis

Section 3

(Likert scales for assessment of the level of agreement with the following statements. 1 – strongly disagree; 10 – strongly agree).

- I believe that a 3D model (printed, digital, or a combination of both) should contribute to more accurate preoperative planning compared to relying solely on imaging exams.
- I believe that the 3D model (printed, digital, or a combination of both) should contribute to better communication/explanation of the surgical procedure to the patient.
- I believe that a 3D model (printed, digital, or a combination of both) should contribute to more accurate planning of the surgery duration.
- I believe that the custom-made rigid prosthesis will exactly match (or with minimal adjustments) the defect reproduced in the 3D model (printed, digital, or a combination of both).
- I believe that the intraoperative findings will be exactly as reproduced by the 3D model (printed, digital, or a combination of both).
- I believe that the 3D model (printed, digital, or a combination of both) will significantly reduce the surgery duration.
- I believe that the 3D model (printed, digital, or a combination of both) will significantly reduce intraoperative bleeding.
- I believe that the 3D model (printed, digital, or a combination of both) may help prevent potential postoperative complications.
- I believe that the 3D model (printed, digital, or a combination of both) positively contributes to the training of less experienced surgeons.
- I believe that the material used in the 3D model printing is similar, in terms of rigidity, to the intraoperative findings.
- I believe that the printing of 3D models is advantageous for all patients undergoing chest wall reconstruction with the placement of a custom-made rigid prosthesis.
- Overall, I think that printing a 3D model is more advantageous compared to a digital 3D model.

Figure 1

Questionnaire used in the survey, translated in English.

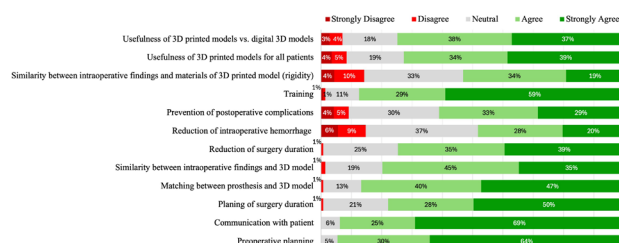


Figure 2

Overall results of the assessment of the level of agreement with a series of statements regarding the usefulness of 3D models in chest wall reconstruction surgery.

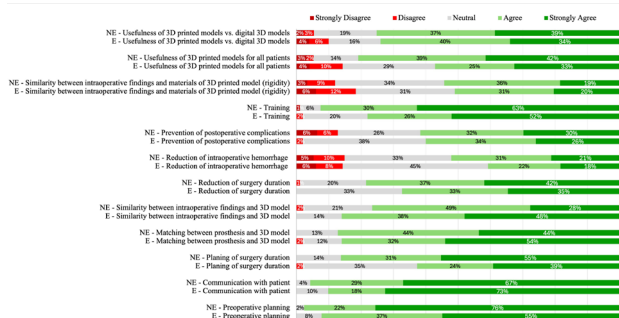


Figure 3

E – Experience; NE – No Experience. Comparison of the level of agreement with each statement regarding the usefulness of 3D models in chest wall reconstruction surgery between the group of surgeons with experience with 3D models and the group of surgeons without experience.

alloplastic materials, and reduction in the total cost and time of the surgery. Also, 3D technologies aid in positioning and shaping newly incorporated tissues with precision resulting in better functional and aesthetic outcomes.⁽⁷⁾

Similarly, 3D models of the chest wall, either 3D printed or digital, may play a relevant role in thoracic surgery, specifically in chest wall reconstruction. It is well established that anterior chest wall defects may result in severe respiratory and circulatory compromise. Defects involving more than 4 or 5 ribs, more than 5 cm in transverse dimension, more than 2 adjacent ribs, or more than 200 cm² can cause a flail chest. To avoid respiratory dysfunction, rigid reconstruction is necessary after anterior chest wall resection.⁽¹²⁾⁽¹³⁾ Reconstruction of the chest wall can be challenging due to the anatomical complexity of the chest wall as well as the various tissue-specific requirements. These models may help engineers and clinicians to develop specific solutions for subjects with chest wall defects.

The aim of this study is to assess the practicality and usefulness of 3D models in clinical practice for chest wall reconstruction surgery.

MATERIALS AND METHODS

This descriptive survey study was distributed to all thoracic surgeons and residents, practicing in the Iberian Peninsula and Latin America, in either public or private sector. After explaining the study design, they were asked to complete an online questionnaire. The distribution of the questionnaire was made through their respective national thoracic societies and responses were collected between July and September 2024. The identity of the respondents was kept anonymous. The questionnaire was created with Microsoft Forms, using an institutional account after consultation with the Data Protection Officer of our institution to ensure compliance with security protocols in place and to guarantee that, since no patient data was involved, there was no need for approval from the Ethics Board.

Questionnaire

The questionnaire contained 4 items regarding identification and experience and 12 items that enquired about the opinion of surgeons with experience working with 3D models of the chest wall and the opinion of those without experience with this technology (Figure 1). Multiple choice questions and Likert scales were used. The level of agreement on a series of statements was assessed on a scale of 0 to 10 and answers were grouped in five categories: 0, 1 - strongly disagree; 2, 3 – disagree; 4, 5, 6 – neutral; 7, 8 – agree; 9, 10 - strongly agree. The questionnaire was written in Portuguese and Spanish to facilitate participant engagement.

Results were analyzed using descriptive statistics and Mann–Whitney U test to access the differences between the two groups. Values of $p \leq 0,05$ were considered significant. The data gathered was analyzed statistically with IBM SPSS Statistics™ version 30.

Table 1 Demographic and surgeons experience results of the survey

	n	%
Sex		
Male	111	76,60%
Female	34	23,40%
Country		
Argentina	24	16,60%
Bolivia	1	0,70%
Brazil	50	34,50%
Chile	3	2,10%
Colombia	4	2,80%
Costa Rica	1	0,70%
Ecuador	5	3,40%
Spain	23	15,90%
Guatemala	1	0,70%
Mexico	4	2,80%
Peru	6	4,10%
Portugal	17	11,70%
Dominican Republic	1	0,70%
Uruguay	1	0,70%
Venezuela	2	1,40%
Undefined	2	1,40%
Level of differentiation		
Resident	19	13,10%
Specialist < 5 years	21	14,50%
Specialist > 5 years	25	17,20%
Specialist > 10 years	34	23,40%
Specialist > 20 years	46	31,70%
Experience with rigid prosthesis with patient specific 3D modeling		
No experience	94	64,80%
With experience	51	35,20%
Number of surgeries performed with rigid prosthesis with patient specific 3D modeling		
< 5 surgeries	35	68,60%
5 - 10 surgeries	9	17,60%
10 - 20 surgeries	5	9,80%
> 20 surgeries	2	3,90%

Table 2

Mann-Whitney U test performed to compare the level of agreement with each statement between the group of surgeons with experience with 3D models and the group of surgeons without experience

Statement	Z test statistic	p-value
The 3D model (printed, digital, or a combination of both) contributed to a more accurate preoperative planning compared to relying solely on imaging exams	-2,101	0,036
The 3D model (printed, digital, or a combination of both) contributed to a better communication/ explanation of the surgical procedure to the patient	-0,424	0,671
The 3D model (printed, digital, or a combination of both) contributed to a more accurate planning of the surgery duration	-2,657	0,008
The custom-made rigid prosthesis matched exactly (or with minimal adjustments) the defect reproduced in the 3D model (printed, digital, or a combination of both)	-0,877	0,38
The intraoperative findings were exactly as reproduced by the 3D model (printed, digital, or a combination of both)	-2,071	0,038
The 3D model (printed, digital, or a combination of both) significantly reduced the surgery duration	-1,23	0,219
The 3D model (printed, digital, or a combination of both) significantly reduced intraoperative bleeding	-0,879	0,379
The 3D model (printed, digital, or a combination of both) helped prevent potential postoperative complications	-0,096	0,923
The 3D model (printed, digital, or a combination of both) contributed positively to the training of less experienced surgeons	-1,717	0,086
The material used in the 3D model printing was similar, in terms of rigidity, to the intraoperative findings	-0,441	0,659
The printing of 3D models is advantageous for all patients undergoing chest wall reconstruction with the placement of a custom-made rigid prosthesis	-2,197	0,028
Overall, printing a 3D model is more advantageous compared to a digital 3D model	-0,563	0,573

RESULTS

A total of 145 answers were gathered from 15 different countries. Most respondents were male (76,6%). Among the total number of respondents, the most participating countries were Brazil (34,5%), Argentina (16,6%) and Spain (15,9%). Regarding seniority, specialists with more than 20 years of experience participated the most, representing 31,7% of all respondents, while residents were the least participating group (13,1%). Most respondents had never performed thoracic wall reconstruction surgeries using a rigid prosthesis with 3D patient-specific planning (64,8% vs. 35,2%), and most of those with previous experience with these models, had only performed less than 5 surgeries (68,6%) (table 1).

Most consensus was obtained regarding the positive contribution of a 3D model for preoperative communication with the patient (69% strongly agreed), improvement in preoperative planning (64,1% strongly agreed), and its positive role in training of less experienced surgeons (59% strongly agreed). A trend for neutral opinion was observed regarding its impact in avoidance of perioperative complications. Regarding 3D printing of a physical model, 74,8% agreed or strongly agreed that it would be advantageous in comparison with a digital model, and 72,8% agreed or strongly agreed that it would be advantageous for all candidates considered for chest wall reconstruction with rigid prosthesis (figure 2).

Regarding model contribution for a more precise preoperative planning and planning of surgery duration, there was a statistically significant difference, with surgeons without experience attributing greater value to it ($z=-2,101$, $p=0,036$; $z=-2,657$, $p=0,008$, respectively). Both surgeons with and without experience with this technology, consider 3D printed models to

be advantageous for all candidates to chest wall reconstruction surgery, however unexperienced surgeons value it significantly more ($z=-2,197$; $p=0,028$). On the other hand, experienced surgeons find higher similarities between intraoperative findings and those reproduced by the 3D model than expected by the other group ($z=-2,071$; $p=0,038$) (table 2, figure 3).

DISCUSSION

Our demographic data indicates that in the Iberian Peninsula and Latin America there is little experience with thoracic wall reconstruction surgeries using a rigid prosthesis with 3D patient-specific modeling. However, the overall opinion on 3D models' usefulness is positive and most consensus was obtained regarding their usefulness in communication with the patient, preoperative planning and training of less experienced surgeons.

These findings indicate that there is acceptance of this technology among thoracic surgeons and suggest that limited access is more related to hindrances to access than acceptance of technology. Barriers to access were not explored and few answers were collected from several countries to correctly evaluate geographic availability. However, according to literature, we hypothesize that the primary barrier to access 3D printing technology could be financial, which is related to the cost of segmentation software, 3D printing machinery, disposable equipment, maintenance, and hiring skilled personnel.⁽¹⁴⁾ Medical 3D printing is still an emerging field, therefore skilled personnel is scarce. A 2016 systematic review of segmentation methods used for 3D printing found that most published studies used manual or semi-automatic segmentation methods over fully automatic ones.⁽¹⁵⁾ The cost of segmentation may decrease with development of fully automatic segmentation software, which

together with lower printer costs due to technology development may lead to greater access to 3D modeling and printing.⁽¹⁵⁾ A complementary or alternative approach to producing physical 3D models is to create digital models using the same source data, which is more cost-effective but does not alleviate the need for skilled personnel with expertise in segmentation. Digital 3D models cannot be physically held and may give the user less precise impressions of depth and proximity between structures.⁽¹⁶⁾ The utility of digital and 3D printed models may vary among users, and the collected data in this study indicate that over 70% of thoracic surgeons agree that 3D printing a physical model is advantageous in comparison with a digital model, and that it is advantageous for all candidates considered for chest wall reconstruction with rigid prosthesis.

Regarding communication, in a review by Traynor et al., the majority of the studies on the use of 3D models for communication, reported positive feedback, irrespective of the type of respondent or type of communication.⁽¹¹⁾ Illmann et al. reported that of the 85% of clinicians who found benefit from the models, 80% of them believed they would facilitate communication with colleagues and 72% believed they would be useful in communication with parents or families.⁽¹⁴⁾ The effect of improved patient-doctor communication should not be underestimated: a 3D printed model allows the visualization of anatomy, haptic handling and reinforces the patient's individuality, which could lead to increased patient understanding and trust. Therefore, increased patient compliance and satisfaction are to be expected.⁽¹¹⁾ However, a minority of studies reported findings on communication that were not exclusively positive. One study reported patients having to emotionally confront the model as a barrier to its utility when faced with their brain tumors.⁽¹⁷⁾ In another study clinicians ranked teaching as the most relevant application for 3D models and communication as the least relevant.⁽¹⁸⁾ In fact, 3D modeling technology has the potential to be used for multiple medical educational initiatives. Our data showed great consensus regarding chest wall 3D models utility in training of less experienced surgeons, but their role may be extended to medical education in universities, to education in the context of Basic or Advanced Life Support courses, among others.

Interesting information arises from the comparison of opinions among surgeons with experience with 3D models and those without experience. Unexperienced surgeons value significantly more the contribution of 3D models for preoperative planning, planning of surgery duration, and their usefulness for all patients undergoing chest wall reconstructive surgery, than experienced surgeons. This should not be interpreted as if those with experience with 3D models undervalue their usefulness, because the level of agreement with these statements is still very high. However, there is great expectation and interest in this technology from the unexperienced group, which may lead to this difference of opinion. On the other hand, experienced surgeons find significantly higher similarities between intraoperative findings and those reproduced by the 3D model, than unexperienced surgeons. Interestingly, those who have worked with these models recognize higher accuracy of the models than expected by the unexperienced group. This observation suggests that their accuracy exceeds expectations.

CONCLUSION

This data suggests that 3D models are not available to most surgeons but may contribute to better outcomes, as there is great agreement among participant surgeons that they allow for better preoperative planning, improved communication with patients and training of less experienced surgeons, among others. 3D printed models are seen as more advantageous than digital models and are considered beneficial for all patients undergoing chest wall reconstruction surgery. To fulfill their role in improving communication with patients, 3D printed models should be available for all patients undergoing chest wall reconstruction surgery during the preoperative consultation, with potentially important implications for patient empowerment and psychological adjustment.

Most, if not all, Thoracic Surgery centers would benefit from access to this technology and, since it is essentially a planning and training tool, the less experienced centers would probably benefit the most.

Limitations

The limitations of this study include the lack of uniformity regarding the quality of the 3D models used in different healthcare institutions, the relatively small sample size and geographic restriction to the selected countries. There is also the potential for response bias, that is, recipients of the survey with a vested interest in 3D modeling would be more likely to respond. However, we received almost double the number of responses from participants without access to the technology than from those with access.

Future perspectives

In the future, it would be interesting and very informative to evaluate the reasons for lack of access to this technology from most surgeons, as well as to correctly evaluate geographic availability.

The role of 3D models in patient-doctor communication was accessed from the doctor's point of view. Inquiries to patients would add relevant information and better enlighten this issue. Another aspect that could be further developed is the contribution of 3D models for better, more precise, communication among specialists.

The potential use of chest wall 3D modeling in real world applications, beyond procedural planning, could deepen and accelerate the development of this technology, which would, in turn, reduce costs and increase its availability.

Immersive 3D and augmented reality technologies are emerging and their application in chest wall reconstruction would be a step further in this field.

ACKNOWLEDGMENTS

We would like to thank the collaboration of all the national scientific societies of Thoracic Surgery from the countries involved in this study, namely the Portuguese Society of Cardiac, Thoracic and Vascular Surgery, the Spanish Society of Thoracic Surgery, and the Brazilian Society of Thoracic Surgery, among all others. A special thanks also to Filipe Pagaimo, MEng, PhD, and Álvaro Fuentes-Martín, MD for their important contribution.

Appendix 1

Secção 1 (Perguntas de escolha múltipla)

- Género
- País
- Experiência como cirurgião torácico
- Experiência com cirurgia de reconstrução da parede torácica com utilização de próteses rígidas e modelação 3D

Se o participante tiver experiência com cirurgia de reconstrução da parede torácica com utilização de próteses rígidas e modelação 3D, é redireccionado para a secção 2, senão, é redireccionado para a secção 3.

Secção 2 (Escala Likert para avaliação do nível de concordância com as seguintes afirmações. 1 – 10; 1 – forte discordância; 10 – forte concordância).

- O modelo 3D (impresso, digital ou a combinação de ambos) contribuiu para um planeamento pré-operatório mais preciso do que se este fosse realizado exclusivamente com acesso aos exames de imagem.
- O modelo 3D (impresso, digital ou a combinação de ambos) contribuiu para uma melhor comunicação / explicação ao doente do procedimento cirúrgico.
- O modelo 3D (impresso, digital ou a combinação de ambos) contribuiu para planeamento mais preciso do tempo operatório necessário para o procedimento.
- A prótese rígida com planeamento à medida do doente corresponde exatamente (ou com ajustes mínimos) ao defeito reproduzido no modelo 3D (impresso, digital ou a combinação de ambos).
- Os achados intraoperatórios foram exatamente os reproduzidos pelo modelo 3D (impresso, digital ou a combinação de ambos).
- O modelo 3D (impresso, digital ou a combinação de ambos) permitiu reduzir significativamente o tempo operatório.
- O modelo 3D (impresso, digital ou a combinação de ambos) permitiu reduzir significativamente a hemorragia intraoperatória.
- O modelo 3D (impresso, digital ou a combinação de ambos) permitiu prevenir eventuais complicações pós-operatórias.
- O modelo 3D (impresso, digital ou a combinação de ambos) contribuiu positivamente para a formação de cirurgiões menos experientes.
- O material utilizado na impressão do modelo 3D era semelhante, sob o ponto de vista de rigidez, aos achados intraoperatórios.
- A impressão de modelos 3D é vantajosa para todos os doentes candidatos a reconstrução da parede torácica com colocação de uma prótese rígida com planeamento à medida do doente.
- De um modo geral, a impressão de um modelo 3D é vantajosa relativamente a um modelo 3D digital.

(Pergunta de escolha múltipla)

- Número de cirurgias realizadas de reconstrução da parede torácica com utilização de prótese rígida com planeamento à medida do doente.

Secção 3 (Escala Likert para avaliação do nível de concordância com as seguintes afirmações. 1 – 10; 1 – forte discordância; 10 – forte concordância).

- Acredito que um modelo 3D (impresso, digital ou a combinação de ambos) deva contribuir para um planeamento pré-operatório mais preciso do que se este for realizado exclusivamente com acesso aos exames de imagem.
- Acredito que o modelo 3D (impresso, digital ou a combinação de ambos) deva contribuir para uma melhor comunicação / explicação ao doente do procedimento cirúrgico.
- Acredito que um modelo 3D (impresso, digital ou a combinação de ambos) deva contribuir para planeamento mais preciso do tempo operatório necessário para o procedimento.
- Acredito que a prótese rígida com planeamento à medida do doente corresponda exatamente (ou com ajustes mínimos) ao defeito reproduzido no modelo 3D (impresso, digital ou a combinação de ambos).
- Acredito que os achados intraoperatórios sejam exatamente os reproduzidos pelo modelo 3D (impresso, digital ou a combinação de ambos).
- Acredito que o modelo 3D (impresso, digital ou a combinação de ambos) permita reduzir significativamente o tempo operatório.
- Acredito que o modelo 3D (impresso, digital ou a combinação de ambos) permita reduzir significativamente a hemorragia intraoperatória.
- Acredito que o modelo 3D (impresso, digital ou a combinação de ambos) possa permitir prevenir eventuais complicações pós-operatórias.
- Acredito que o modelo 3D (impresso, digital ou a combinação de ambos) contribua positivamente para a formação de cirurgiões menos experientes.
- Acredito que material utilizado na impressão do modelo 3D seja semelhante, sob o ponto de vista de rigidez, aos achados intraoperatórios.
- Acredito que a impressão de modelos 3D seja vantajosa para todos os doentes candidatos a reconstrução da parede torácica com colocação de uma prótese rígida com planeamento à medida do doente.
- De um modo geral, penso que a impressão de um modelo 3D é vantajosa relativamente a um modelo 3D digital.

Appendix 2

Sección 1 (Preguntas de opción múltiple)

- Género
- País
- Experiencia como cirujano torácico
- Experiencia con cirugía de reconstrucción de la pared torácica con utilización de prótesis rígidas y modelado 3D

Si el participante tiene experiencia con cirugía de reconstrucción de la pared torácica utilizando prótesis rígidas y modelado 3D, será redirigido a la sección 2; de lo contrario, será redirigido a la sección 3.

Sección 2 (Escala Likert para evaluar el nivel de acuerdo con las siguientes afirmaciones. 1 – 10; 1 – fuerte desacuerdo; 10 – fuerte acuerdo).

- El modelo 3D (impresso, digital o la combinación de ambos) contribuyó a una planificación preoperatoria más precisa que si se hubiera realizado exclusivamente con acceso a exámenes de imagen.
- El modelo 3D (impresso, digital o la combinación de ambos) contribuyó a una mejor comunicación / explicación al paciente sobre el procedimiento quirúrgico.
- El modelo 3D (impresso, digital o la combinación de ambos) contribuyó a una planificación más precisa del tiempo operatorio necesario para el procedimiento.
- La prótesis rígida con planificación personalizada para el paciente correspondía exactamente (o con ajustes mínimos) al defecto reproducido en el modelo 3D (impresso, digital o la combinación de ambos).
- Los hallazgos intraoperatorios fueron exactamente los reproducidos por el modelo 3D (impresso, digital o la combinación de ambos).
- El modelo 3D (impresso, digital o la combinación de ambos) permitió reducir significativamente el tiempo operatorio.
- El modelo 3D (impresso, digital o la combinación de ambos) permitió reducir significativamente la hemorragia intraoperatoria.
- El modelo 3D (impresso, digital o la combinación de ambos) permitió prevenir posibles complicaciones postoperatorias.
- El modelo 3D (impresso, digital o la combinación de ambos) contribuyó positivamente a la formación de cirujanos menos experimentados.
- El material utilizado en la impresión del modelo 3D era similar, en cuanto a rigidez, a los hallazgos intraoperatorios.
- La impresión de modelos 3D es ventajosa para todos los pacientes candidatos a la reconstrucción de la pared torácica con la colocación de una prótesis rígida con planificación personalizada.
- En general, la impresión de un modelo 3D es más ventajosa en comparación con un modelo 3D digital.

(Pregunta de opción múltiple)

- Número de cirugías realizadas de reconstrucción de la pared torácica con utilización de prótesis rígida con planificación a medida del paciente.

Sección 3 (Escala Likert para evaluar el nivel de acuerdo con las siguientes afirmaciones. 1 – 10; 1 – fuerte desacuerdo; 10 – fuerte acuerdo).

- Creo que un modelo 3D (impresso, digital o la combinación de ambos) debe contribuir a una planificación preoperatoria más precisa que si se realiza exclusivamente con acceso a exámenes de imagen.
- Creo que el modelo 3D (impresso, digital o la combinación de ambos) debe contribuir a una mejor comunicación / explicación al paciente sobre el procedimiento quirúrgico.
- Creo que un modelo 3D (impresso, digital o la combinación de ambos) debe contribuir a una planificación más precisa del tiempo operatorio necesario para el procedimiento.
- Creo que la prótesis rígida con planificación personalizada para el paciente corresponde exactamente (o con ajustes mínimos) al defecto reproducido en el modelo 3D (impresso, digital o la combinación de ambos).
- Creo que los hallazgos intraoperatorios son exactamente los reproducidos por el modelo 3D (impresso, digital o la combinación de ambos).
- Creo que el modelo 3D (impresso, digital o la combinación de ambos) permite reducir significativamente el tiempo operatorio.
- Creo que el modelo 3D (impresso, digital o la combinación de ambos) permite reducir significativamente la hemorragia intraoperatoria.
- Creo que el modelo 3D (impresso, digital o la combinación de ambos) podría permitir prevenir posibles complicaciones postoperatorias.
- Creo que el modelo 3D (impresso, digital o la combinación de ambos) contribuye positivamente a la formación de cirujanos menos experimentados.
- Creo que el material utilizado en la impresión del modelo 3D es similar, en cuanto a rigidez, a los hallazgos intraoperatorios.
- Creo que la impresión de modelos 3D es ventajosa para todos los pacientes candidatos a la reconstrucción de la pared torácica con la colocación de una prótesis rígida con planificación personalizada.
- En general, pienso que la impresión de un modelo 3D es más ventajosa en comparación con un modelo 3D digital.

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