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Value of Individualized Breast 3D Printing in Doctor-patient Communication and Patient Psychology

Yuanyuan Lu[a, d, #], Ruoxiu Xiao[b, #], Kunlun He[c,d,*], Junlai Li[a,*], Muxi Zha[b], Xinmeng Guo[b], Weigang Li[b], Tong Lu[e]

Abstract

Background: Significance of breast 3D printing based on MRI and ultrasound in accurate preoperative design and efficient pre-operative communication is research in this paper.

Methods: Sixty-six breast occupying lesions were collected from the department of breast surgery, Chinese PLA General Hospital, all of which were malignant lesions. They were randomly divided into three groups of conventional, MRI 3D printing and ultrasound 3D printing. The differences in the efficiency of preoperative doctor-patient communication and accuracy of preoperative planning were analyzed by scale scoring.

Results: There were significant differences in the overall scores of patients' understanding (condition, treatment and prognosis) and patients' satisfaction (surgical results, treatment confidence and communication mode) in conventional group, ultrasound group and MRI group ($F=199.645$; $P = 0.000$). From high to low, the scores were: ultrasound group > MRI group > conventional group. There were significant differences among these three groups: $P_{1,2}=0.000$; $P_{1,3}=0.000$; $P_{2,3}=0.000$. The difference had statistical significance ($P <0.05$). The satisfaction score of preoperative planning was scored by doctors for three ways, and these three groups had remarkable differences ($F=28.152$; $P = 0.000$). From high to low, scores were: ultrasound printing group > MRI group > conventional group. There were obvious differences among three groups: $P_{1,2}=0.000$; $P_{1,3}=0.025$; $P_{2,3}=0.000$. The difference was statistically significant ($P <0.05$).

Conclusions: The application of 3D printing can improve the effects of preoperative doctor-patient communication, accuracy of preoperative surgical planning plan, patients' satisfaction with communication mode and doctors' satisfaction with surgical plan.

Key words: Breast Occupation; 3D Printing Technology; Doctor-patient Communication; Preoperative Planning

Introduction

Mammary gland is one of the most important organs for women, and its surgical treatment is closely related to the quality of patients after surgery. Impact on patients' psychology, marriage, etc. [2-5-9-12,13]. There is a significant difference in the impact of breast-conserving surgery and radical breast surgery on patients' quality of life after surgery [11, 17]. While the indications for breast-conserving surgery are closely related to the patients' wishes 23. Effective communication with the patient before surgery can enable the patient to intuitively and accurately understand the condition, overcome fear, and correctly express subjective wishes. This is the basis to ensure that the patient chooses a reasonable surgical method [4, 19].

[a]Department of Ultasound, The Second Medical Center of Chinese PLA General Hospital, Beijing, 100853, China
[b]School of Computer and Communication Engineering, University of Science and Technology Beijing, Beijing 100083, China
[c]Translational Medicine Laboratory, Chinese PLA General Hospital, Beijing, 100853, China
[d]Key Laboratory of Ministry of Industry and Information Technology of Biomedical Engineering and Translational Medicine, Chinese PLA General Hospital, Beijing, 100853, China
[e]Beijing Visual 3D Medical Science and Technology Development, CO. LLC, Beijing 100070, China
[#]Yuanyuan Lu and Ruoxiu Xiao contributed equally to this work.
[*]Corresponding authors: Junlai Li, Translational Medicine Laboratory, Chinese PLA General Hospital, No. 28, Fuxing Road, Haidian District, Beijing 100853, China, Tel: +86-15600218571, Email: L_jl@yeah.net.
Kunlun He, Translational Medicine Laboratory, Key Laboratory of Ministry of Industry and Information Technology of Biomedical Engineering and Translational Medicine, Chinese PLA General Hospital, No. 28, Fuxing Road, Haidian District, Beijing 100853, China, Email: kunlunhe@plagh.org.

Literature review

The use of individualized breast 3D printing models can visualize and three-dimensionally show the breast lesions of patients [1, 3, 7, 14, 15, 20, 22]. It is hoped that patients can have a more rational understanding of their own condition through the intuitive display of 3D printing. At the same time, it is also convenient for doctors to introduce the patient's condition and make the next surgical plan so that the patient can make a reasonable surgical choice to lay the foundation for the next treatment

[6, 10, 16, 18, 21, 24, 25].

1 Clinical data and research methods

1.1 Case collection

Sixty-six patients with breast cancer who were admitted to the department of breast surgery of Chinese PLA General Hospital from January 2018 to January 2019 and met the inclusion criteria were collected.

Inclusion criteria: (1) Patients were 18-50 years old; (2) The diagnosis of malignant breast occupying lesions was confirmed by pathological examination; (3) The patient's family agreed that the patient knows; (4) Patients without breast-conserving surgery contraindications according to the 2017 edition of China Anti-Cancer Association Breast Cancer Diagnosis and Treatment Guidelines; (5) It was planned to perform breast surgery in our hospital; (6) The patients underwent breast MRI in our hospital before surgery; (7) The patients underwent ABVS ultrasonic examination in our hospital before surgery; (8) The patients had no communication barriers (language, hearing, intelligence); (9) The patients signed the informed consent.

Exclusion criteria: 1) Male patients; 2) Breast cystic, inflammatory and other non-solid space-occupying lesions; 3) Patients with breast hyperplasia; 4) Family members requested to conceal the patient's condition; 5) Communication disorder (language, hearing and intelligence); 6) Patients who were not receive preoperative MRI, ABVS and puncture pathological examination; 7) After inclusion, it was found that the research object included does not meet the criteria for inclusion; 8) Patients included in the study group who did not follow the study protocol; 9) The actual surgery was not completed according to this study protocol.

Age: 24-50 years old, average age: 35.6 years old. The nodule was measured in the range of 10-37 mm. Histopathology included: 18 cases of ductal carcinoma in situ (27.3%); 49 cases of invasive ductal carcinoma (74.2%); 5 cases of invasive lobular carcinoma (7.6%). 2 cases of lobular carcinoma in situ (3.0%); 1 case of mucinous adenocarcinoma (1.5%); 1 case of medullary carcinoma. Three multiple lesions and five diffuse lesions were excluded (each patient obtained informed consent before ABVS examination, the subject was approved by the ethics committee of the PLA General Hospital).

1.2 Instrument

All instruments: ultrasound instrument: Siemens S2000 Automated Breast Volume Scanner (ABVS), probe length 20cm, scanning height of 20cm, layer thickness of 0.525mm, Continuous automatic tomography. MRI: GE750, Simemens skyro, etc. 3.0 T; 8 channel coil, 1mm thick layer. Breast MRI and ABVS 3D reconstruction are segmented and reconstructed by medical professionals. 3D reconstruction: the Dicom data obtained by MRI and ABVS ultrasound are imported into Mimics 18.0 (Materialise), and the breast, tumor, vessels and other tissues are segmented by manual segmentation based on threshold segmentation and boundary outline. After segmentation, the 3D model is saved in STL format. 3D printing equipment and color: by Beijing Visual 3D Medical Science and Technology Development, CO. LLC.

1.3 Research methods

The computer randomly selected the group, the study was divided into the conventional group, the MRI 3D reconstruction image 3D printing group and the ultrasound 3D reconstruction image 3D printing group.

(1) Conventional group: according to the traditional communication methods, mainly according to the results of patients' ultrasonic reports, the patients were introduced to the patient's condition and surgical plan for doctor-patient communication; Preoperative discussion and preoperative planning were conducted according to the doctor's palpation, ultrasonic examination or breast MRI results.

(2) MRI 3D reconstruction image and 3D printing group: A complete reconstructed image of the patient's prone breast was obtained through breast MRI, and a 1:1 ratio 3D printing model of the separable material of unilateral breast was carried out (**Fig. 1**).

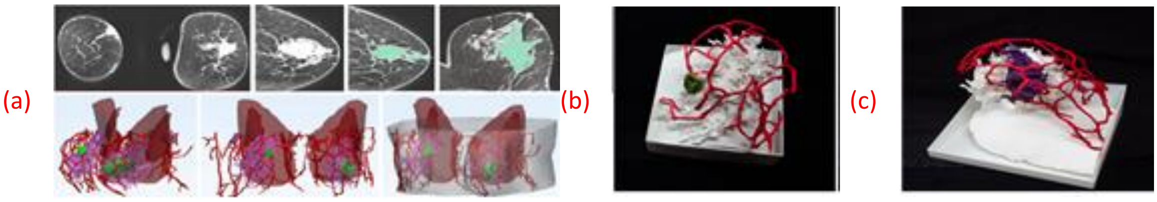

Fig. 1. **Breast 3D printing based on MRI. (a) 3D reconstruction of tumor, nipple, gland, pectoralis major and other parts in breast; (b) 3D printing of right breast; (c) 3D printing of left breast.**

(3) Ultrasonic 3D reconstruction image and 3D printing group: Three-dimensional reconstruction of the unilateral complete breast by breast ultrasound ABVS (the team realized three-dimensional reconstruction of the sequence ultrasound image of the unilateral complete breast by designing a fully closed and adjustable closed water tank in the preliminary study 14) was fully transparent and integrated 3D printing of a 1:1 ratio unilateral breast model (**Fig. 2**).

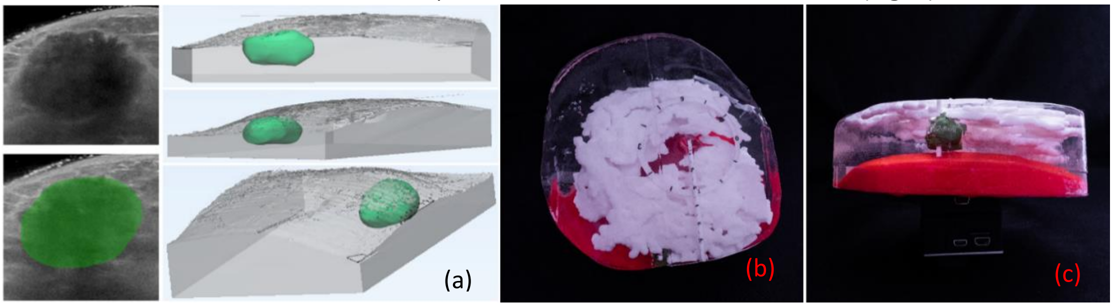

Fig. 2. **Breast 3D printing based on ultrasound image. 3D reconstruction of tumor and breast; (b) vertical of 3D breast printing. A ruler and angle scale are added for measurement. (c) Side view of 3D breast printing.**

1.4 Observation evaluation index:

(1) The doctor-patient communication questionnaire and the preoperative discussion questionnaire were designed respectively in the pre-test. A total of 100 outpatients in our hospital were randomly selected to investigate the problems concerned in doctor-patient communication, and the 10 breast surgeons were selected to investigate the specific problems concerned in preoperative discussion.

(2) Doctor-patient communication scale: communication time; Patient understanding; The proportion of choosing breast-conserving surgery in this group; Patient acceptance of surgical results; Patients' confidence in treatment; Patient satisfaction with communication style.

(3) Preoperative plan discussion scale for 3D printing group and control group: preoperative plan discussion time; In-depth preoperative planning discussion; The degree of agreement between the surgical plan and the actual surgical situation.

1.5 Statistical methods

SPSS 22.0 statistical software is used to analyze the data. The measurement data of the normal distribution is expressed by x ± s, and the analysis of variance is used for comparison. The pairwise comparison is performed by the LSD method. Count data should be compared by chi-square analysis. Statistically significant with P <0.05.

1.6 Quality control:

(1) The above detection methods are completed by our hospital's fixed inspectors and the designated imaging doctors cooperate with the 3D reconstruction staff to manually segment and measure the pictures; (2) The database is managed by specialized person.

2 Research results

2.1 General clinical information of patients:

Analysis of randomly grouped cases according to the main influencing factors that might affect patients' choice of surgery, comparing the number of patients, average age, left and right breast ratio, tumor size (including long diameter, width, and height), education years, annual income and marital status among the conventional group, the MRI printing group and the ultrasound printing group, and no significant difference was found in the results (**Table 1**).

Table 1. **Basic situation of patients**

Groups	Conventional (n=22)	Ultrasound printing (n=22)	MRI printing (n=22)	F	P
Average age (years)	41.046±6.835	38.863±6.081	41.091±7.131	0.795	0.456
Left breast / Right breast	11/11	13/9	10/12	0.487	0.784
Tumor length (mm)	18.514±6.546	20.514±8.160	16.514±7.835	0.578	0.564
Tumor wide (mm)	15.268±4.356	16.786±4.546	13.989±6.542	0.865	0.426
Tumor height (mm)	15.641±4.611	18.741±6.475	16.542±5.721	2.583	0.084
Education years	13.000±2,794	12.863±2,550	12.046±3.184	0.719	0.491
Annual income (thousand)	123.18±209.93	89.09±83.72	94.55±72.75	3.93	6.77
Marital Status (Married / Unmarried / Divorced)	18/1/3	16/3/3	17/2/3	1.118	0.891

2.2 Evaluation results of patients' satisfaction with doctor-patient communication:

Based on the results of the preoperative questionnaire, the statistics of the doctor-patient communication satisfaction scale were performed. The statistics of the scale were carried out when the patients were discharged after the hospitalization treatment, which expresses the true degree of patient satisfaction. Scale statistical results were as follows.

Doctor-patient communication time: (1) The time when doctors interpreted the condition showed a significant difference among the three groups (F=6.967; P=0.002), the time for doctors in the conventional group to interpret the condition was less than that in the ultrasound printing group ($P_{1,2}$=0.001) and the MRI 3D printing group ($P_{1,2}$=0.001). However, there was no significant difference in disease interpretation time between the ultrasonic printing group and the MRI 3D printing group ($P_{2,3}$=0.414). (2) The question time of patients showed a significant difference among the three groups (F=35.802; P=0.000), patients in the ultrasonic 3D printing group had more questions than those in the conventional group ($P_{1,2}$=0.000) and the MRI 3D printing group ($P_{2,3}$=0.000). However, there was no significant difference in question time between the conventional group and the MRI 3D printing group ($P_{2,3}$=0.414). (3) The doctor's response time showed a significant difference among the three groups (F=92.335; P=0.000), the corresponding time length of the three groups was: the ultrasound 3D printing group > MRI 3D printing group > conventional group, which was corresponding to the question time of the patients. The response time of doctors in the ultrasonic 3D printing group was longer than that in the MRI 3D printing group ($P_{2,3}$=0.000). The MRI 3D printing group lasted longer than the conventional group ($P_{1,3}$=0.014). (4) The total length of communication time was significantly different among the three groups (F=60.498; P=0.000), the corresponding time length of three groups: ultrasonic 3D printing group > MRI 3D printing group > conventional group. The total communication time of the ultrasonic 3D printing group was longer than that of the MRI 3D printing group ($P_{2,3}$=0.000). The communication time of the MRI 3D printing group was longer than that of the conventional group ($P_{1,3}$=0.000).

Through the communication methods of the three groups, the understanding degree of the patients on the condition, treatment and prognosis: (1) the understanding degree of the patients on the condition showed a significant difference between the three groups (F=47.504; P=0.000), and the understanding score of patients in the conventional group was lower than that in the ultrasound 3D printing group ($P_{1,2}$=0.000) and the MRI 3D printing group ($P_{1,3}$=0.000). However, there was no significant difference in patients' understanding of the disease between the ultrasound printing group and the nuclear magnetic 3D printing group ($P_{2,3}$=0.600). (2) The score of patients' understanding of the treatment scheme showed that there were significant differences among the three groups (F=26.921; P=0.000), the scores of the three groups were ranked from high to low as follows: the ultrasound 3D printing group > the MRI 3D printing group > the conventional group, and there were significant differences among the three groups: $P_{1,2}$=0.000 ; $P_{1,3}$=0.003 ; $P_{2,3}$=0.000. Patients in the ultrasound 3D printing group had a better understanding of the treatment plan than those in the conventional group and the MRI 3D printing group, and the patients in the MRI 3D printing group had a better understanding of the condition than those in the conventional group. (3) The score of the understanding degree of the patients on the prognosis and the next treatment method showed a significant difference among the three groups (F=61.342; P=0.000). The scores of the three groups were ranked from high to low as follows: the ultrasound 3D printing group > the MRI 3D printing group > the conventional group, and there were significant differences among the three groups: $P_{1,2}$=0.000 ; $P_{1,3}$=0.000 ; $P_{2,3}$=0.000. Patients in the ultrasound 3D printing group had a higher understanding of the prognosis and the next treatment than those in the conventional group and the MRI 3D printing group, which in turn were higher than those in the conventional group.

The patients were graded according to the degree of agreement with the expected results of preoperative surgery, postoperative treatment confidence and satisfaction degree of communication methods: (1) The score of agreement with the expected results of preoperative surgery showed a significant difference among the three groups (F=23.75; P = 0.000). The score of the ultrasound 3D printing group was higher than that of the MRI 3D printing group and the conventional group ($P_{1,3}$=0.000 ; $P_{2,3}$=0.009), and the score of the MRI 3D printing group was higher than that of the conventional group ($P_{1,3}$=0.000). (2) The score of patients' confidences in postoperative treatment showed a significant difference among the three groups (F=26.937; P = 0.000). The scores of the conventional group wer lower than those of the ultrasonic 3D printing group ($P_{1,3}$=0.000) and the MRI 3D printing group ($P_{1,3}$=0.000). There was no significant difference between the MRI 3D printing group and the ultrasonic 3D printing group ($P_{2,3}$=0.403). (3) The satisfaction score of the patients with the communication method showed a significant difference among the three groups (F=87.987; P = 0.000). The scores of the conventional group were lower than those of the ultrasound 3D printing group ($P_{1,3}$=0.000) and the MRI 3D printing group ($P_{1,3}$=0.000). The scores of the MRI 3D printing group were higher than those of the ultrasonic 3D printing group, with no significant difference between the two groups ($P_{2,3}$=0.387).

The comparison of the understanding degree and the total score of satisfaction of the patients resulted in a significant difference among the three groups (F=199.645; P = 0.000). From high to low, the scores were: the ultrasound3D printing group > MRI 3D printing group > the conventional group. There were significant differences among the three groups: $P_{1,2}$=0.000 ; $P_{1,3}$=0.000 ; $P_{2,3}$=0.000. (**Table 2**).

Table 2. **comparison of doctor-patient communication indicators (x+s) in preoperative conventional group, ultrasound 3D printing group and MRI 3D printing group for breast cancer.**

Groups		Conventional (n=22)	Ultrasound printing (n=22)	MRI printing (n=22)	F/X²	P	$P_{1,2}$	$P_{1,3}$	$P_{2,3}$
Communication Time (min)	Doctors interpret the condition	3.18+0.795	4.36+0.73	4.09+1.57	6.97	0.002	0.001	0.008	0.414
	Patient questions	2.27+0.88	4.86+0.94	2.82+1.33	35.80	0.000	0.000	0.096	0.000
	Doctors answer	1.91+0.68	5.14+0.71	2.55+1.06	92.34	0.000	0.000	0.014	0.000
	Total time	7.45+1.06	13.05+0.79	9.45+2.65	60.50	0.000	0.000	0.000	0.000
Understanding scores	Condition	3.09+0.53	4.50+0.60	4.59+0.59	47.50	0.000	0.000	0.000	0.600
	Treatment	3.05+0.66	4.55+0.67	3.68+0.72	26.92	0.000	0.000	0.003	0.000
	Prognosis	2.73+0.70	4.64+0.49	3.82+0.50	61.34	0.000	0.000	0.000	0.000
	Surgical result	3.00+0.76	4.50+0.67	3.91+0.75	23.75	0.000	0.000	0.000	0.009
Communication satisfaction	Treatment confidence	2.50+0.51	3.95+0.65	3.77+0.92	26.94	0.000	0.000	0.000	0.403
	Way of communication	2.95+0.65	4.68+0.48	4.82+0.39	87.99	0.000	0.000	0.000	0.387
Total understanding and satisfaction scores		17.32+0.81	26.82±1.29	24.59±1.79	199.65	0.000	0.000	0.000	0.000
Breast-conserving surgery (ratio%)		5（22.7%）	8（36.4%）	8（36.4%）	1.26	0.533	0.322	0.322	1.000

Note: $P_{1,2}$: compare the conventional group with the ultrasound 3D printing group; $P_{1,3}$: compare the conventional group with the MRI 3D printing group; $P_{2,3}$: compare the ultrasound 3D printing group with the MRI 3D printing group.
* * express P < 0.05

2.3 Preoperative plan and physician satisfaction scale results:

Statistics of preoperative plan and doctor satisfaction scale based on preoperative questionnaire results. The statistical results of the three groups of scales were as follows.

In-depth preoperative planning discussion (including specific location of surgical incision; Surgical incision plan length). (1) Scoring according to the specific content of the doctor's preoperative plan and the actual surgical results, indicating that the specific design of the surgical incision location of the three groups was significantly different (F=59.460; P=0.000), and the scores of the ultrasound 3D printing group were higher than those of the conventional group ($P_{1,2}$=0.000) and the MRI 3D printing group ($P_{2,3}$=0.000) with statistical significance. However, there was no significant difference in preoperative incision location setting between the MRI 3D printing group and the conventional group ($P_{1,3}$=0.295). (2) In terms of the length of planned surgical incision before operation, the score was based on the degree of agreement with the final actual surgical result, and there was a significant difference among the three groups (F=9.828; P=0.000), both the 3D printing groups score higher than the conventional group ($P_{1,2}$=0.000 ; $P_{1,3}$=0.000), and there was no significant difference between the MRI 3D printing group and the ultrasound 3D group ($P_{2,3}$=1.000).

Doctors make preoperative plans using ultrasound 3D printing, MRI 3D printing and traditional methods respectively, and scored the plans according to their satisfaction. Results of the scores of different ways showed significant differences among the three groups ($F=28.152$; $P = 0.000$). From high to low, the scores were: the ultrasound 3D printing group > MRI 3D printing group > the conventional group. The significant differences among the three groups were $P_{1,2}=0.000$; $P_{1,3}=0.025$; $P_{2,3}=0.000$ (**Table 3**).

Table 3. **Preoperative plan and doctor satisfaction score (x+s) of the conventional group, the ultrasound 3D printing group and the MRI 3D printing group**

Group		Conventional (n=22)	Ultrasound printing (n=22)	MRI printing (n=22)	F	P	$P_{1.2}$	$P_{1.3}$	$P_{2.3}$
Plan discussion before surgery	Incision position	2.55+0.91	4.68+0.48	2.77+0.69	59.460	0.000	0.000	0.295	0.000
	Incision length	3.59+0.67	4.32+0.57	4.32+0.65	9.828	0.000	0.000	0.000	1.000
Doctors satisfaction		3.05+0.58	4.41+0.59	3.48+0.68	28.152	0.000	0.000	0.025	0.000

Note: $P_{1,2}$: compare the conventional group with the ultrasound 3D printing group; $P_{1,3}$: compare the conventional group with the MRI 3D printing group; $P_{2,3}$: compare the ultrasound 3D printing group with the MRI 3D printing group.

3 Discussion

From the results of studies, 3D printing of individualized breast and lesion models is more conducive to patients' understanding of the disease, treatment and prognosis than before. For breast cancer patients, they not only face the threat from disease, but also face the mental damage of the incomplete body after breast surgery. Therefore, allowing patients to correctly understand their pathological conditions before surgery, the choice of treatment options and the problems faced by different treatment options after surgery, and actively choose the treatment plan that suits them according to their own wishes, so that it is more beneficial to breast cancer patients postoperative recovery and confidence in next treatment.

From the results of the patients' satisfaction with the final surgical results and the confidence in the treatment in this study, we can see that comparing the traditional text description with the 3D printing individualized model for doctor-patient communication, the 3D model can significantly improve the patient's satisfaction with the surgical result and the next treatment confidence. From the patient's satisfaction with the communication method, we find that patients are more willing to accept MRI 3D printing methods, because compared with the ultrasound breast 3D model printing, MRI can make the breast structure more stereo and beautiful. The findings also indirectly prove that female patients are more inclined to beautiful physical communication. At the same time, a detailed, specific, and accurate preoperative plan is a guarantee for successful surgery. In this study, the traditional method of drawing a preoperative plan based on the description of the tumor's approximate location, shape and size is changed to a three-dimensional physical expression. That is, the size and morphology of the tumor can be fully expressed, and the tumor can be expressed in the breast space, which is more conducive to the doctor's accurate surgical planning. From the results of the study, we can conclude that the specific length of the preoperative surgical incision and the convenience of the doctor are significantly higher in the 3D printing group than in the traditional method. In terms of the specific location of the preoperative incision, the method of ultrasound 3D printing is significantly better than the other two groups [8]. In the MRI 3D printing group, the position of tummy position and supine position during surgery have a great influence on the deformation of breast organs, and it is difficult to accurately locate, therefore, the MRI group did not perform significantly better than the conventional group in guiding the setting of the surgical incision position.

Limitations: In the process of use, we constantly encounter new problems. For example, the sink bracket we are using is designed according to the probe size of the existing ABVS scanner, which is suitable for some patients; moreover, the silicone film we choose for the water tank should not only meet the load bearing capacity of the water tank, but also be thin enough to minimize the impact on the image quality. At the same time, 3D printing is expensive and the number of beneficiaries is very limited. Therefore, we propose a new idea and method. In this study, the image is returned to the essence of image expression, and the information obtained from the image is directly converted into three-dimensional image physical expression, so as to achieve complete and accurate transmission of clinical information. However, the traditional way is to transform the image inspection information into the indirect mark of text for expression, which is bound to affect the integrity and accuracy of information transmission. It is hoped that this method can draw people's attention to the development of 3D image reconstruction technology and provide more valuable services for patients and clinicians.

Study implication

In conclusion, the application of 3D printing can improve the effect of preoperative doctor-patient communication, accuracy of preoperative surgical planning plan, patients' satisfaction with communication mode and doctors' satisfaction with surgical plan.

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Conflict of Interest

The authors declare that they have no competing interests.

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