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Review Article

The Accessible Clinical Application Progress of Supine Fixation Technique in Radiotherapy After Breast Conserving Surgery for Early Breast Cancer in China

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Abstract

Radiation therapy (radiotherapy) is one of the important methods for comprehensive treatment of breast cancer. Radiotherapy after breast conserving surgery for early breast cancer can not only achieve local control rate and long-term survival rate similar to total mastectomy, but also meet patients' pursuit of higher quality of life. With the development of intensity modulated radiotherapy (IMRT), volumetric modulated arc therapy (VMAT), helical tomotherapy (HT), and other advanced radiotherapy technique, the consistency of patient position fixation during radiotherapy is the key to ensure the implementation of accurate radiotherapy. Due to the special and high activity of breast organs, there is no unified fixation method for breast conserving postoperative radiotherapy. This article reviews the clinical application and research progress of various accessible supine fixation techniques in early breast cancer postoperative radiotherapy in recent years. This paper analyzes the clinical application method and clinical application effect of various techniques, compares the advantages and disadvantages of each technology. It is found that breast bracket is the most widely used for classical breast cancer radiotherapy. In any fixation technique, it is still a practical problem for the clinic to solve the problem of the normal location of the breast activity and the consistency of the radiation. It is recommended that the position of the supposition fixation technique should be selected according to the patient's BMI, breast size and target area.

Keywords

Breast Conserving Surgery, Intensity Modulated Radiotherapy (IMRT), Supine Position, Position Fixation

1. Introduction

Breast cancer is a malignant tumor that seriously affects the physical and mental health of women, and its incidence and mortality rank first and fifth respectively in Chinese female malignant tumors [1]. Male breast cancer is a relatively rare malignant tumor, and its incidence is much lower than that of female breast cancer. In recent years, the number of male breast cancer patients has gradually increased [2]. In 2019, the Breast Cancer Professional Committee of the Chinese Anti-Cancer Association issued the «Guidelines and Norms for the Diagnosis and Treatment of Breast Cancer of the Chinese Anti-Cancer Association (2019 edition)», which clarified the principles of breast cancer treatment as follows: Multi-disciplinary comprehensive treatment is recommended, and various treatment means currently available in China are

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reasonably applied to maximize and guarantee curative effect, while reducing acute and chronic adverse reactions and the risk of complications as much as possible, so as to guarantee beauty, function and quality of life [3]. Radiotherapy is one of the most important means of comprehensive treatment of breast cancer (surgery, radiotherapy, chemotherapy, targeted therapy and immunotherapy, etc.). Breast-conserving postoperative radiotherapy is an important means to reduce recurrence and prolong survival cycle, and can achieve the same local control and long-term survival as total mastectomy, so as to guarantee the quality of life of early breast cancer patients [4]. In 2021, the Chinese Medical Doctor Association Radiation Oncologist Branch led the formulation of the «Chinese Guidelines for Radiation Therapy of Breast Cancer (2020 edition)» (referred to as the guidelines), which solved the problem that there is no unified radiation therapy standard for breast cancer treatment in China. Breast is a non-rigid organ with special position and difficult to fix, which seriously affects the accurate implementation of intensity modulated radiotherapy and even adversely affects the therapeutic effect of radiotherapy [5]. At present, there is no uniform standard of position fixation for postoperative radiotherapy after breast-conserving surgery. In 2021, the Radiotherapy Technology Group of the Radiation Oncology Branch of the Chinese Medical Association issued the «Chinese Expert Consensus on Clinical Operation Guidelines for CT Simulated Positioning Technology (2021 edition)» (referred to as the consensus), providing recommendations for breast cancer radiotherapy position fixation [6]. How to solve the problem of difficult position fixation in postoperative breast conserving radiotherapy has become a hot topic in clinical research. This paper reviews the characteristics and research progress of various accessible supine fixation techniques in recent years.

2. Necessity of Good Position Fixation for Radiotherapy After Breast-Conserving Surgery

ICRU83 report pointed out that improving the accuracy of body position fixation can reduce the expansion value between the clinical target volume (CTV) and the planned target volume (PTV) of IMRT, and reduce the exposure of normal tissues [7]. Accurate body position fixation technology is the key to achieve dose advantage and quality assurance of IMRT. The setup error and repeatability are the important indexes of postural fixation evaluation. ICRU24 report pointed out that the setup error is the main factor affecting the dose volume parameters of IMRT, and the setup error exceeding 5mm will increase the average dose of the target area and endanger the increase of the illuminated dose of the organ [8]. Target dose deviation of 5% may cause the primary lesion to be out of control or increase complications, while target dose deviation of 3%-5% may lead to the decrease of the effective rate of radiotherapy in the primary tumor and the increase of the probability of radiation complications in the surrounding normal tissue. During the radiotherapy, the effect of setup error reaching 3mm will decrease by 3.3%, and the effect reaching 5mm will decrease by 18.4%; A 0.5mm linear error in any direction of the patient or a 2 °rotation error results in a 5% change in the target dose [9]. Therefore, in clinical practice, the translation error of 5mm and rotation error of 2 °are often used as the basis for judging the success of positioning.

The setup errors during radiotherapy were mainly caused by the setup errors of between sessions, target location shift and deformation between sessions, respiratory movement within sessions and involuntary movement of patients. The target areas of postoperative radiotherapy have the following characteristics: wide range of target areas, including breast, chest wall, upper and lower clavicle area, armpit, etc. The motion of the target area was large, and the patient's body size and breast size had great influence on the pose repeatability. Affected by respiratory movement, the range of change is large; Postoperative seroma and deformation, silver clip migration, inflammatory changes in skin, muscles, glands and other soft tissues caused by radiotherapy, body wasting, meat tension and skin tension, and uplifting of arms [10, 11]. All these factors pose a challenge to the good fixation of radiotherapy position after breast-conserving surgery, so stable, comfortable and efficient fixation methods are extremely necessary.

3. Clinical Characteristics of Various Postural Fixation Techniques

Common postural fixation methods include breast bracket, vacuum negative pressure pad, polyfoam board, thermoplastic film/thermoplastic molding mesh cover, and other individual fixation methods. The combination of thermoplastic film and vacuum pad, thermoplastic film and polyfoam board, thermoplastic film and breast bracket, vacuum pad and breast bracket is fixed. And the combined application of respiratory management techniques [1, 6]. The position mode is generally supine, considering the efficiency of the position and dosimetry effect [12, 13]. Multiple studies have shown that supine position has more advantages than prone position in positioning accuracy and repeatability of postoperative radiotherapy for breast preservation [14, 15].

1) Breast bracket fixation technique

Breast bracket is a traditional breast fixation device with standardized features. Its tilt Angle, arm bracket, wrist throw, head pad, hip clamp, knee pad and other components are adjusted, and the breast tissue can be fully exposed during the implementation of radiotherapy, so that patients can obtain relatively comfortable and personalized position, and ensure the repeatability of radiotherapy [16]. It can well solve the connection problem between the patient's position and each irradiation field, and can also improve the uniformity of ra-

diotherapy dose in breast cancer patients, especially in young patients with thin body and good body balance, and has been widely used in clinical practice [17]. Due to its own structural limitations, the following problems were found in clinical practice [18-20]: the rigid structure of the bracket could not fully contact the patient with the substrate, and the fitting degree was not ideal, and it was easy to rotate and shift left and right during positioning and treatment; Inability to immobilize the breast and limit respiratory movement in the chest; Postoperative cicatricial contracture makes it difficult to maintain the same Angle of upper arm elevation and abduction. Immobilization, such as no knee brace, can cause the body to slide due to gravity, tension or discomfort; The head pillow is a round soft pillow can not completely fix the head and ensure the height of chin lift, which affects the treatment of cervical lymph node target area. The structure is relatively complex, and the operation steps of therapist positioning are many, which is easy to increase the source of error; The parameter value is adjusted to the finite fixed file, which can not fully realize the individualized body position fixation. The fixation effect on soft tissue is poor, and the skin stretching is easy to occur in patients with fat body type. After more than 30% of patients were fixed with a simple breast bracket, the error of the abdomen and back, head and feet, and the left and right three positioning directions was > 5mm.

The adjustment of the tilt Angle of the bracket support is often used in early radiotherapy to reduce radiation exposure to normal lung tissue. Intensity modulation radiotherapy can better protect lung tissue through multi-dimensional and multi-parameter dose irradiation, and the demand for breast bracket support plate tilt is gradually reduced. Studies have shown that 0 degree bracket has no difference in dosimetry compared with other degree brackets (7 degrees, 7.5 degrees, 12 degrees), and the setup error and repeatability are more advantageous [21, 22].

2) Vacuum negative pressure pad fixing technology

Most vacuum negative pressure pads used in clinical practice are regular rectangles, and the target area of postoperative breast-conserving radiotherapy requires the shoulders and arms to be fixed and extended well. Conventional vacuum pads generally have the following disadvantages [23, 24]: limited in size, they cannot effectively wrap and fix the head and arms of patients, and certain gaps will be generated between the fixed pads and the back when the arms are raised, and the fixing accuracy in the direction of head, feet and abdomen and back is poor. It is a passive fixation method, which cannot be actively filled with the body and can only be achieved by manually stacking the particles in the sealed bag. Poor use is easy to leak gas; Relevant reports suggest that the fixation accuracy of vacuum pad in breast cancer radiotherapy needs to be improved.

Some specially customized large-size vacuum pads, wider than the general vacuum pad, can fix the body, neck, shoulders and upper limbs; At the same time, the head can be combined with the head pillow or leave enough space to lean back to ensure that the head and neck are fixed and fully exposed; With the help of the patient's own gravity, the stability of the left and right orientation can be guaranteed. Studies have shown that the specially customized vacuum pad has more positioning advantages than the breast bracket [25, 26].

3) Polyfoam board fixing technology

Polyfoam board fixation has been applied in head and neck tumor radiotherapy due to its active shaping, stable structure, high fixation accuracy and good placement repeatability [27, 28]. It has the following characteristics: strong plasticity, by increasing the foaming agent capacity and different size waterproof bags can be fixed on different body types of patients or special sites of tumors; The active foaming agent creates upward extrusion pressure on the human body, which can fully fill the space of the patient's body and completely cover the whole head, arm, neck, chest and upper abdomen. After forming, the structure is firm, the nature is stable, there is no air leakage problem; Individualized production can effectively prevent infection caused by secondary use; Naturally lying flat can reduce the sagging mammary gland due to the action of gravity, skin folds; Compared with vacuum pad, the fixed accuracy and repeatability are better [29-31].

4) Thermoplastic film/thermoplastic mesh cover fixing technology

The thermoplastic film used alone after breast preservation surgery is generally the head, neck and shoulder thermoplastic film. When the patient is fixed in the position, the supine position on the horizontal body frame can eliminate the influence of gravity factors, and the body film can wrap the head, neck and mammary gland to better limit the displacement caused by breathing movement and subconscious body movement. Clinical applications generally include removing the thermoplastic film in the affected chest wall or breast radiotherapy area and retaining the thermoplastic film in the area [32]. The former is to fully expose the irradiated area and ensure that the dose is not affected by the fixed device; The latter is to shape the breast through thermoplastic film, fix the position of the breast, and prevent the deformation of breast tissue caused by the extrusion of the thermoplastic film on the breast [33, 34]. The clinical concern is that thermoplastic film may increase the influence of skin dose and increase the setup error of skin traction. Studies have shown that based on intensity modulated radiotherapy technology, thermoplastic body modeling not only does not significantly increase skin damage, but also reduces the uncertainty of target area caused by organ movement by restricting respiration, and reduces the left-right and rotation errors [35]. Compared with not removing the irradiated thermoplastic film, the positioning accuracy is not affected, and the adverse reactions on the skin are relatively reduced [33]. It is also recommended in guidelines and consensus to keep the treated breast open and free from compression [1, 6]. Another disadvantage of thermoplastic film is that it is contractile to a certain extent after cooling and fixation, which may cause the contraction of the

thermoplastic film to squeeze the breast or other parts to change the location of the target area, especially for patients with fuller breasts. The change of the patient's body shape will also cause the weakening of thermoplastic film fixation and the displacement [36, 37]. In clinical practice, compared with the breast bracket, it has better performance in translation and rotation dimensions, and the success rate of one placement is higher [35].

5) Breast bracket and thermoplastic film/vacuum negative pressure pad/foam combination fixation technology

Due to the inherent defects of breast bracket, it is often used in combination with thermoplastic film, vacuum pad and polyfoam board in clinical practice.

The combination of breast bracket and thermoplastic film can be divided into thermoplastic head mold, thermoplastic thoracic peritoneum, thermoplastic body mold, thermoplastic head, neck and shoulder mold, and the bracket is generally placed flat. The thermoplastic head film can fix the patient's head and maintain the stability of the chin during each position, reduce the error of neck rotation and head and foot direction, and contribute to the consistency of the upper and lower clavicle target area [38]. The pleuroperitoneum was placed in the chest of the patient and completely wrapped the breast. The thermoplastic film had no significant improvement on the left and right direction, head and foot direction and rotation direction. Considering that the pleuroperitoneum had not removed part of the body model of the affected breast, the reason for the lack of improvement in the positioning accuracy was considered [34, 39]. The thermoplastic body membrane is placed at the upper abdominal boundary of the patient and about 2cm below the lower mammary margin, which can limit the error of chest breathing. The body membrane placed on the abdomen of the patient can avoid the deformation caused by squeezing of the breast during film-making and positioning, and avoid adverse skin reactions. It can ensure that the abduction height and Angle of the patient's hands and the level of the body can be well stretched to ensure comfort, and the position of the arm and the body can be better fixed, and the positioning accuracy is higher [40, 41]. Compared with the 0-degree bracket combination and the single head-and-shoulder mold, the head-and-neck and chest integrated mold (removing the affected side body mold) has smaller head and foot setup errors and better shoulder joint fixation [42]. Combined with thermoplastic film fixation, marking points are not marked on the patient's body surface, which can avoid the impact of mark erasure. The combination of thermoplastic film and breast bracket can not only give full play to the advantages of breast bracket, but also limit the error caused by chest respiratory movement through thermoplastic film [43].

The combination of breast bracket and vacuum pad is to place the negative pressure vacuum pad on the bottom plate of the breast bracket, and pile up the vacuum pad to make it fully contact with the patient's neck and body. The vacuum pad can adjust the lying Angle of the patient to improve the comfort. The position of the patient and the bracket is relatively fixed, and the repeatability and accuracy of the positioning are improved by fixing the head, arm and body. Compared with a single breast bracket, left and right, head and foot setup errors and positioning success rates are better [44, 45]. Studies have shown that, compared with breast bracket + thermoplastic film fixation technology, this technology is affected to some extent by arm discomfort caused by postoperative scar contracture, as well as repetitive and setup errors [43]. In some studies, only adding vacuum pad to the buttocks of the breast bracket also achieved better results than using the breast bracket alone [46].

The polyfoam board itself is more advantageous than the negative pressure vacuum pad. The edge of the foam pad covers both sides of the patient. The back should be fully in contact with the foam pad to shape the torso. It can achieve completely individualized fixation of different patient sizes, and has obtained a higher fixation accuracy than breast brackets [47, 48].

6) Thermoplastic film and vacuum pad fixation technology

Thermoplastic film covering the patient's chest and abdomen mold and cutting the omentum at the breast irradiation site can reduce the gap between the patient's back and the vacuum pad, improve the fit degree of the shoulder and back and the personalized fixation pad, and reduce the external release value of the target area compared with the vacuum pad alone [23, 24]. Although the thermoplastic membrane can restrict the movement of patients from left to right, it is insufficient to restrict the movement of patients in the direction of head and foot. If the thermoplastic is directly compressed on the breast tissue, there will be errors in the front and back directions each time the position is placed; Breast size was also associated with setup errors, with larger breasts squeezing more. The combination of thermoplastic film and vacuum pad without cutting the affected side body model has no advantage over the positioning of the breast bracket [16]. Some researchers made the vacuum pad into an inclined plane similar to the breast bracket, and covered the thermoplastic body membrane from the lock to the root of the thigh, while paying attention to the shape of the legs, waist, armpit, mammary gland and other parts; The results showed that the triadic translation error was superior to that of the breast bracket [49] when the hip area was fixed by the rectal cancer bottom plate.

4. Lateral Comparison of Various Fixing Techniques Based on Setup Errors

Good posture fixation technology is the key to ensure accurate radiotherapy, and the target extension value calculated based on setup error is also a necessary way to guide the delineation of clinical target areas. The success rate of positioning is a sign of the repeatability of fixation techniques. The following are selected data related to various fixation techniques after breast conserving surgery with comprehen-

sive information, so as to make a horizontal comparison of the advantages and disadvantages of each technique, as shown in Table 1.

Table 1. *Comparison of fixation techniques of radiotherapy after breast conservation based on setup error.*

Year	Data source	fixation techniques	Case number	purpose of research	setup error (X, Y, Z)	Target margin (X, Y, Z)	research conclusion
2015 [18]	Beijing Cancer Hospital	Breast bracket$^{\mu}$	52^{①*D}	Breast bracket positioning precision factors	1.52 ±0.66, 2.18 ±1.02, 1.86 ±0.92mm	4.26, 6.16, 5.29mm	(The positioning success rate is 85%, The positioning accuracy of breast bracket is good)
2015 [25]	Affiliated Cancer Hospital of Guangxi University	Wedge head and shoulder vacuum pad	26^{①*A}	The fixed technique extends the target margin	2.5 ±2.5, 2.3 ±2.2, 1.9 ±2.2mm	8.0, 7.3, 6.3mm	(Positioning success rate 75%, Wedge-shaped head and shoulder pads have good positioning accuracy)
2015 [33]	The First Affiliated Hospital of Chongqing Medical University	Breast bracket + body membrane (neck, chest, upper abdomen)	36^{②*D}	Verify the feasibility of the fixing technique	2.6 ±0.783, 3.0 ±1.027, 1.6 ±0.872mm	7.05, 8.22, 4.61mm	(The positioning success rate is 80%, Breast bracket + body membrane (breast shaping) fixation effect is good and low abdominal and back error)
2015 [37]	Sichuan Provincial People's Hospital	Breast bracket + thermoplastic mold (chest) with Breast bracket$^{\mu}$	30^{⑧*D}	Comparative positioning error	Breast bracket + thermoplastic mold: 4.0 ±0.81, 3.8 ±0.8, 2.7 ±0.79mm; Breast bracket: 2.6 ±0.94, 2.7 ±0. 7, 2.5 ±0.75mm	10.57, 10.06, 7.30mm; 7.16, 7.24, 6.78mm	(If the thermoplastic film does not remove part of the breast body model on the affected side, it will have an adverse effect on the setup error)
2016 [45]	Gulou Hospital Affiliated to Nanjing University School of Medicine	Breast bracket + vacuum pad and breast bracket$^{\alpha}$	64^{⑧*D}	Comparative positioning error	Breast bracket + vacuum pad: 1.261 ±0.014, 1.636 ±0.930, 1.962 ±1.163mm; breast bracket: 1.309 ±1.273, 1.926 ±1.816, 1.896 ±1.239mm	3.16, 4.74, 5.72mm; 4.16, 6.09, 5.61mm	(Vacuum pad + breast bracket is better for position fixation)
2016 [50]	Jiujiang First People's Hospital	Breast bracket Gamma with vacuum pad + Thermoplastic film (lock to thigh root)	115^{②*D}	Comparative positioning error	Breast bracket: 3.25 ±0.92, 3.88 ±0.94, 3.92 ±0.96mm; vacuum pad + Thermoplastic film: 2.02 ±0.13, 2.3 ±0.41, 2.11 ±0.35mm	8.77, 10.36, 10.47mm; 5.14, 6.29, 5.52mm	Wedge vacuum pad + Thermoplastic film more advantages (Breast shaping)
2017 [20]	Suzhou Municipal Hospital	Breast bracket$^{\mu}$	13^{①*A}	Verify the feasibility of improved breast bracket headrest	Before improvement: 2.89 ±2.52, 3.96 ±2.97, 4.21 ±2.24mm;	8.00, 8.00, 6.00mm; 4.07, 4.03,	Personalized headrest with breast bracket can reduce the position error of the upper clavicle

Year	Data source	fixation techniques	Case number	purpose of research	setup error (X, Y, Z)	Target margin (X, Y, Z)	research conclusion
					After improvement) 2.16 ±1.25, 1.50 ±1.28, 1.94 ±1.12mm	3.73mm	
2017 [24]	First Affiliated Hospital of Xiamen University	Vacuum pad + thermoplastic film (not explained) with vacuum pad	116⑤*D	Comparative positioning error	Vacuum pad + thermoplastic film: 2.19 ±1.77, 3.02 ±3.09, 2.65 ±3.54mm; Vacuum pad: 4.01 ±3.33, 3.68 ±2.78, 4.4 ±3.5mm	6.71, 9.69, 9.08mm; 12.31, 11.12, 13.12mm	The positioning success rates were 66% and 41%, respectively, and the vacuum pad plus thermoplastic film helped to improve the positioning accuracy
2017 [34]	Wuzhou Red Cross Hospital	Breast bracket + thermoplastic membrane (chest and abdomen) and breast bracketμ	44②*D	Comparative positioning error	Breast bracket + thermoplastic membrane: 4.12 ±0.834, 3.81 ±0.843, 2.78 ±0.745mm; breast bracke: 2.91 ±0.734, 2.67 ±0.657, 2.59 ±0.717mm	10.88, 10.11, 7.47mm; 7.79, 7.13, 6.98mm	If the thermoplastic film does not remove part of the breast body model on the affected side, it will have an adverse effect on the setup error
2017 [36]	General Hospital of Shenyang Military	Head, Neck and shoulder thermoplastic film	16②*D	Verify the feasibility of the fixing technique	3.102 ±1.864, 3.342 ±2.088, 2.133 ±1.739mm	9.06, 9.82, 6.55mm	The positioning success rate is 78.5%, The head, neck and shoulder thermoplastic film can shape and position the breast with good repeatability
2017 [39]	Henan Cancer Hospital	Breast Bracket + Thermoplastic membrane (Chest and abdomen) With breast bracketμ	60②*D	Comparative positioning error	Breast bracket: 2.5 ±0.751, 2.6 ±0.951, 2.7 ±0.674mm; Breast bracket + thermoplastic membrane: 2.7 ±0.785, 4.0 ±0.789, 3.8 ±0.801mm	6.78, 7.17, 7.22mm; 7.30, 10.56, 10.06mm	Breast bracket fixation is better than breast bracket + thermoplastic film (the external body model of the affected breast is not removed and the breast is not shaped
2017 [40]	Henan Cancer Hospital	Breast bracket + body model (upper body membrane boundary lower breast margin) and breast bracketα	40②*D	Comparative positioning error	Breast bracket + body model: 1.52 ±0.41, 1.39 ±0.43, 1.43 ±0.31mm; Breast bracket: 2.21 ±1.39, 2.09 ±1.41, 2.18 ±1.7mm	4.09, 3.78, 3.79mm; 6.50, 6.21, 6.64mm	Breast bracket + body model can reduce setup errors and improve accuracy (body model is located under the breast without squeezing the breast, and can control breathing amplitude)
2018 [10]	Cancer Hospital, Chinese Academy of	Deep Inspiration Breath Holding (DIBH) technology	15②*A	Evaluate the setup error of DIBH+ breast	1.9 ±1.3, 2.1 ±1.3, 2.0 ±1.4mm	5.7, 6.2, 6.0mm	DIBH+ breast bracket has good repeatability and small error

Year	Data source	fixation techniques	Case number	purpose of research	setup error (X, Y, Z)	Target margin (X, Y, Z)	research conclusion
	Medical Sciences	+ Breast bracket[μ]		bracket			
2018 [15]	Sichuan Province Cancer Hospital	Supine breast bracket [μ] and prone breast bracket + thermoplastic membrane	20[⑧*D]	Compare the advantages and disadvantages of two fixed methods	Supine breast bracket: 0.6 ±2.30, 0.42 ±2.44, 3.23 ±2.95mm; prone breast bracket + thermoplastic membrane: -1.54 ±3.19, 1.15 ±7.90, 3.50 ±3.46mm	3.11, 2.76, 10.14mm; 6.08, 8.41, 11.18mm	Supine breast bracket has more advantages than prone position
2018 [16]	Fujian Province Cancer Hospital	Breast bracket [μ] with vacuum pad + Thermoplastic film (not explained)	60[⑧*D]	Compare the advantages and disadvantages of two fixed methods	Breast bracket: 0.27 ±3.61, 0.63 ±4.19, -0.37 ±5.05mm; vacuum pad + Thermoplastic film: 0.64 ±3.25, -2.03 ±4.51, 2.47 ±2.67mm	3.20, 4.51, 4.46mm; 3.88, 8.23, 8.04mm	The placement success rate was 73.3% and 63.4%, and the breast frame was better than the vacuum pad + thermoplastic model repeatability (the affected breast had thermoplastic film extrusion).
2018 [26]	Neijiang Second People's Hospital	Thermoplastic membrane (8cm from the neck to the lower margin of the healthy breast) and vacuum pad	37[②*D]	Comparative positioning error	Thermoplastic membrane: 4.2 ±0.89, 3.8 ±0.72, 2.8 ±0.69mm; vacuum pad: 2.74 ±0.56, 2.4 ±0.48, 2.68 ±0.72mm	11.12, 10.0, 7.48mm; 7.24, 6.34, 7.20mm	Vacuum pad has better positioning effect than thermoplastic film (thermoplastic film extrusion on the affected breast is unknown)
2018 [29]	Sun Yat-sen Memorial Hospital, Sun Yat-sen University	polyfoam board	16[⑧*D]	Verify the feasibility of the fixing technique	0.06 ±2.685, 0.04 ±2.552, 0.38 ±2.188mm	2.03, 1.89, 2.48mm	The positioning success rate is 95%, Foamed colloidal position fixation method has good position repeatability and high stability
2019 [19]	Cancer Hospital, Chinese Academy of Medical Sciences	Breast bracket[μ]	15[①*A]	Breast bracket target margin	2.2 ±1.7, 3.1 ±2.5, 3.3 ±2.3mm	6.39, 10, 8.57mm	The expandable boundary from CTV to PTV below the breast bracket is 6-10mm
2019 [30]	Cancer Hospital, Chinese Academy of Medical Sciences	polyfoam board and vacuum pad	40[①*A]	Comparative positioning error	polyfoam board: 0.55 ±1.16, 0.62 ±1.37, 0.26 ±1.32mm; vacuum pad: 0.51 ±1.61, 1.08 ±1.82, 0.59 ±1.65mm	2.19, 2.51, 1.57mm; 2.40, 3.97, 2.63mm	The positioning accuracy and repeatability of foam are better than that of vacuum pad
2019 [35]	Hangzhou Cancer Hospital	Head and shoulder body thermoplastic membrane (supra-	34[①*C]	Comparative positioning	Thermoplastic body membrane: 0.56 ±2.18,	2.65, 4.36, 2.87mm; 5.71, 6.07,	(A wide range of head and shoulder thermoplastic body film (breast

Year	Data source	fixation techniques	Case number	purpose of research	setup error (X, Y, Z)	Target margin (X, Y, Z)	research conclusion
		clavicular to thigh root) and Breast bracket[α]		error	1.38±2.28, 0.86±1.64mm; Breast bracket: 2.44±1.18, 1.7±3.82, 1.54±1.6mm	4.2mm	shaping) can reduce setup errors and reduce PTV expansion value, and the advantages are more obvious in patients with high BMI)
2019 [43]	Affiliated Cancer Hospital of Xinjiang Medical University	Breast bracket + thermoplastic body membrane (not illustrated) and breast bracket + vacuum pad[μ]	30[⑧*D]	Comparative positioning error	Breast bracket + thermoplastic body membrane: 1.07±1.66, 0.51±1.74, 0.68±1.70mm; breast bracket + vacuum pad: 1.95±2.27, 2.03±2.72, 1.61±2.44mm	3.84, 2.49, 2.89mm; 6.46, 6.98, 5.73mm	Breast bracket + Thermoplastic body membrane positioning accuracy is higher (the specific application of thermoplastic body membrane is unknown)
2019 [44]	Guangdong agricultural Reclamation Central Hospital	Vacuum pad + breast bracket and breast bracket[μ]	86[⑧*D]	Comparative positioning error	Vacuum pad + breast bracket: 1.362±0.128, 1.628±0.416, 1.752±0.225mm; breast bracket: 1.795±0.436, 1.915±0.544, 1.787±0.316	3.49, 4.36, 4.54mm; 4.79, 5.17, 4.69mm	Vacuum pad + breast bracket can reduce setup error
2019 [48]	Cancer Hospital, Chinese Academy of Medical Sciences	polyfoam board and breast bracket[α]	24[①*A]	Comparative positioning error	polyfoam board: 1.03±0.56, 0.97±0.71, 0.73±0.56mm; breast bracket: 1.14±0.8, 1.38±0.93, 0.83±0.72mm	2.97, 2.92, 2.21mm; 3.41, 4.09, 2.59mm	polyfoam board positioning accuracy is higher
2020 [38]	First Affiliated Hospital of Xiamen University	Breast bracket + head mold and breast bracket[μ]	63[②*D]	Comparative positioning error	Breast bracket + head mold: 2.20±1.06, 3.04±1.08, 2.64±1.25mm; breast bracket: 4.00±1.89, 3.69±1.19, 4.30±1.96mm	6.24, 8.36, 7.48mm; 11.32, 10.06, 12.12mm	Placement success rates of 89% and 82.5%, Breast bracket + head film can reduce setup error, improve positioning repeatability and accuracy
2021 [21]	Peking Union Medical College Hospital	breast bracket[αβ]	24[①*A]	Discuss the best elevation Angle of breast bracket	0 degree: 0.28±0.24, 0.37±0.26, 0.38±0.31cm; 7.5degree: 0.31±0.28, 0.53±0.34, 0.46±0.35cm	0.49, 0.55, 0.52cm; 0.64, 0.80, 0.60cm	The 0 degree setup error of the breast bracket is less than 7.5 degrees, and the clinical priority is 0 degrees
2021	Cancer Hospital, Chinese	Neck and chest integrated model	32[②*D]	Verify the feasibility of neck	breast area: 2.09±3.07,	7.37, 6.71,	Cervical and thoracic integrated model +

Year	Data source	fixation techniques	Case number	purpose of research	setup error (X, Y, Z)	Target margin (X, Y, Z)	research conclusion
[42]	Academy of Medical Sciences	(head, neck, chest and abdomen) + breast bracket$^{\alpha}$		and chest integrated mold + bracket	2.08±2.15, 1.53±1.79mm; Subclavicular region: 1.98±3.1, 2.02±2.17, 1.62±1.68mm	5.08mm; 7.12, 6.57, 5.23mm	bracket setup error is small, mammary gland and upper and lower clavicle target area position consistency is good (all of the affected side of the breast external body model)

Note: The positioning error is expressed in the following ways: ① represents systematic error (standard deviation of all individual systematic errors) ± random error (average of all individual random errors); ② represents systematic error (mean of all individual positioning errors) ± random error (standard deviation of all individual positioning errors); ③ represents the unknown; ✶ indicates absolute values of all placement errors, ❊ indicates no absolute values, and ✯ indicates unknown. Extended value calculation: A represent $mPTV = 2.5\Sigma + 0.7\delta$, B represents $mPTV = 2.5\Sigma + 0.7\delta - 3$, C represents $mPTV = 2\Sigma + 0.7\delta$, D represents unknown; α represents the breast bracket Angle 0 degrees, β, γ represents the breast bracket 7.5 degrees, 15 degrees, μ represents unknown; The italics of the expanded value outside the target area are calculated by the author according to the corresponding literature description.

The target margin corresponding to postural radiotherapy fixation technology reported in China from 2015 to 2021 was summarized, and the mean ± standard deviation of multiple groups of data and the mean value of few groups of data were expressed, as shown in Table 2 below.

Table 2. *Comparison of target expansion values for fixation techniques of postoperative radiotherapy for breast preservation.*

	A	B	C	D	E	F	G	H	I	J	K	L
X/mm	6.4±2.1	5.2	7.5±4.1	7.6±4.4	7.1	9.6±1.9	4.0	7.3	4.4±1.8	5.9	2.4±0.5	5.7
Y/mm	7.2±1.9	6.2	7.2±2.9	8.1±3.2	8.2	10.2±0.3	3.1	6.7	5.4±1.4	8.0	2.4±0.5	6.2
Z/mm	6.6±2.4	5.6	7.3±4.3	5.6±2.4	4.6	8.3±1.5	3.3	5.2	5.3±0.7	7.3	2.1±0.5	6.0

Note: A represent breast bracket, B represent Breast bracket + head improvement, C represent Vacuum pad, D represent Thermoplastic film - Chest shaping, E represent Bracket + neck, chest and abdomen thermoplastic film - Chest shaping, F represent Bracket + Head, neck and chest thermoplastic film - non-chest shaping, G represent Bracket + abdominal thermoplastic membrane, H represent Bracket + head, neck and chest thermoplastic film - Buckle the affected side body film, I represent Bracket + vacuum pad, J represent Vacuum pad + Thermoplastic film - Chest shaping, K represent polyfoam board, L represent Bracket +DIBH.

The target margin corresponding to postural radiotherapy fixation technology reported in China from 2015 to 2021 was summarized, and the mean ± standard deviation of multiple groups of data and the mean value of few groups of data were expressed, as shown in Table 2.

5. Analysis of Other Factors Affecting the Positioning Accuracy of Radiotherapy After Breast-Conserving Surgery

1) Patient physiological factors

Studies have shown that the body mass index, chest circumference and breast volume of patients after breast conservation surgery are correlated with setup errors [50, 51]. When patients with body mass index (BMI) > 24kg/m^2 were fixed by breast bracket, the setup errors in X, Y and Z directions were more than 5mm, while the setup errors in all directions were less than 3mm in patients with BMI < 24kg/m^2. Translation errors of patients with different BMI in the two groups were 2.09±1.46, 1.64±0.28, 2.59±0.59mm and 1.68±0.36, 1.47±0.16, 1.77±0.3mm, respectively [52]. Patients who are overweight or have large mammary glands, such as under the position of the inclined support plate, are more likely to have relative displacement of the body surface markers and the irradiation target area, which increases the difficulty of positioning. Raza et al. [53] compared the effect of breast size on the repetition of placement, and found that

patients with larger breast size had larger translational placement errors, and this group of people generally had higher BMI. It is also recommended that whole breast radiotherapy with PTV > 1000cm3 be carried out in prone position to reduce cardiac and left anterior descending coronary artery volume [6]. Due to the physiological differences between Asians and Europeans and Americans, the target area cannot be uniformly 7mm externally placed according to the RTOG1304 test standard in clinical practice. Therefore, appropriate fixation techniques should be selected according to the physiological factors of patients, and reasonable target area expansion value should be calculated [54].

2) CT scanning and image guidance

The target area after breast-conserving surgery is greatly affected by respiratory movement. Some studies used 4DCT to observe the displacement of the target area after breast-conserving surgery, and found that the downward movement of free breathing can reach 3-5mm, resulting in a maximum increase of about 20% in PTV [55, 56]. Thermoplastic body membrane fixation helps to reduce abdominal and dorsal displacement caused by respiratory movement, which has been confirmed in a number of studies. DIBH is a commonly used exercise management technique in clinical practice, which can better control respiratory movement and reduce the volume of the target area, and also help to reduce the difficulty of body position fixation [57, 58].

Setup errors are generally obtained by radiography techniques such as EPID, kV-CBCT, MVCT and other image guidance methods. It has been reported that there is no significant correlation between setup errors and matching methods for breast cancer [59]. kV-CBCT is used in clinical linear accelerators, while MVCT is used in TOMO. Generally, anatomic density registration is performed through lateral anterior thorax and sternum or manual registration with titanium clips. For patients with larger breasts, gray matching is superior to bone matching [60]. Surface profile imaging technology is a new auxiliary positioning technology developed in recent years, which can monitor the three-dimensional surface profile of patients during radiotherapy without introducing additional radiation. Relevant studies have shown that this technology can obtain similar results to kV-CBCT in clinical practice, and has been applied in some medical units in China and achieved satisfactory results [61, 62].

3) Radiation therapists standardized operation

Radiation therapists must first master the attributes of various fixed devices, choose reasonable postural fixation technology according to the patient's own situation, and ensure that the patient is in a comfortable state of body modeling through adequate education, so that the fixed device will fully wrap the patient during the production process. If regional lymph node irradiation is required in the CT scan of patients undergoing breast preservation surgery, it is recommended to enhance CT to facilitate the delineation of target areas in the armpit, upper and lower clavicular region, and internal milk region. At the same time, the upper, lower, medial and lateral boundaries of the breast region should be marked with metal lines, and the surgical scars of the tumor bed should be marked on the metal surface. In the first week of accelerator treatment, the setup error is generally large and there may be large singular value, which is related to the patient's familiarity and fitness. Therefore, it is generally recommended to perform image guidance for each treatment in the first week. Studies have shown that the setup error will be significantly reduced after 1-2 weeks, and it is recommended to reduce the image guidance frequency after 1-2 weeks [20]. The position of the radiotherapist should follow the pattern of double position and cross check. Some medical units set a low laser light in the computer room to reduce the height of positioning, so as to facilitate the therapist's arm to adjust around the patient's body, and check the mark line on the opposite side of the body, so as to reduce the difficulty of positioning and improve the efficiency of positioning [62].

6. Summary and Outlook

According to the clinical application reports of the supine fixation technique of accessible postoperative radiotherapy for breast cancer preservation in China, the breast bracket is the most widely used as a classical radiotherapy fixation device for breast cancer. A number of literatures have confirmed that the 0 degree bracket can achieve better position fixation effect than other Angle brackets under IMRT. The corresponding target area expansion value is 6-8mm in three directions when applied alone, and can be reduced to 3-7mm when combined with the head membrane, peritoneum or vacuum pad. Due to the limitation of the size of the vacuum pad, a special large volume vacuum pad is generally used in clinical practice. The target area expansion value is 7-9mm when applied alone, and the X and Y orientation errors can be appropriately reduced when combined with the thoracic peritoneum. The thermoplastic film is generally applied in combination with the breast bracket or integrated plate to remove the body model on the affected side of the breast corresponding to the target area expansion value of 5-8mm, and the positioning consistency is good for the cervical target area. polyfoam board has been introduced into the clinic in recent years, and its biggest feature is that it can truly realize individual fixation, and can reduce the external expansion value of the target area to about 3mm. The results of the literature review in this paper are basically consistent with the postural fixation methods recommended in guidelines and consensus.

No matter what kind of posture fixation method, it is still a practical problem to solve the large breast motion and maintain the position consistency during radiotherapy. Some researchers have considered the design of a bra similar to the personalized fixed accessories, in the premise of no dosimetric impact to achieve good breast fixation. The combined application of respiratory management technique and respiratory gating technique can help to control the range of motion in the target area and reduce the difficulty of postural fixation

technique. Surface contour imaging technology is expected to reduce the time of image guidance, reduce the operation of body surface marking when the body position is fixed, and avoid unnecessary dose exposure. For the target area expansion value, the appropriate fixation device should be selected according to the patient's BMI value, breast size, and target range (whether there is a target area above and below the clavicle), and the corresponding target area expansion value should be calculated to guide the accurate delineation of the clinical target area. Truly achieve accurate positioning, accurate delineation, accurate planning, accurate treatment.

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Conflicts of Interest

The authors declare no conflicts of interest.

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