Project Name: Evaluation of Aesthetic Outcomes and Safety of 3D-Printed Degradable Biological Mesh for Immediate Breast Reconstruction afterRadical Mastectomy - A Prospective, Single-Center, Single-Arm Clinical Study

Informed Consent Form

Department in Charge: Department of Thyroid, Breast and Vascular Surgery

Principal Investigator: Zhang Juliang

Study Duration: December 2025 - December 2028

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Dear Patient:

You are invited to participate in a clinical trial entitled "Evaluation of Aesthetic Outcomes and Safety of 3D-Printed Degradable Biological Mesh for Immediate Breast Reconstruction after Radical Mastectomy - A Prospective, Single-Center, Single-Arm Clinical Study". This study is led by Professor Zhang Juliang. The research will strictly adhere to the Declaration of Helsinki and relevant laws and regulations of China.

Before deciding whether to participate in this clinical study, please carefully read the following information, which will help you fully understand why this study is being conducted, the procedures and duration of the study, and the potential benefits, risks, and discomforts that may result from participating in the study. You may discuss this with your family members and friends and ask questions of the responsible doctor, who will explain any concerns you may have about this study to help you make a final decision.

I. Study Background

Breast cancer has become the most common malignant tumor among women worldwide and the number one threat to the physical and mental health of women in China. In recent years, breast cancer patients worldwide have shown a younger trend, with patients aged 35-45 accounting for 20%-30% in China. Fortunately, significant advances in early screening and comprehensive treatment over the past three decades have significantly improved the overall survival rate of breast cancer. Surgery remains the core component of comprehensive breast cancer treatment. However, although total mastectomy can effectively control local tumors, postoperative breast loss causes significant physical and psychological trauma to patients, affecting quality of life.

Therefore, breast reconstruction has become an important part of breast cancer surgery. Currently, subcutaneous glandular resection with preservation of the nipple-areola complex followed by immediate prepectoral breast reconstruction has gained international consensus due to its advantages of hidden incisions, minimal trauma, and rapid recovery. Literature reports indicate that the immediate implant reconstruction rate for early breast cancer patients has reached 40%-60% in European and American countries, and this proportion has exceeded 30% in large medical centers in first-tier cities in China. However, in clinical practice, the shape of the surgical cavity formed after subcutaneous glandular resection is significantly heterogeneous due to tumor location, resection range, and differences in patient thoracic anatomy. The existing standardized prostheses cannot fully adapt to the surgical cavity shape, which may lead to prosthesis displacement, rotation, and ptosis. These issues not only affect the aesthetic outcome of reconstruction but also may increase the risk of capsular contracture. Therefore, mesh-assisted fixation has become a key technical method to solve prosthesis stability, with core functions including: supporting the prosthesis and maintaining breast contour, filling the defect space in the surgical cavity, isolating the prosthesis from surrounding tissues to reduce inflammatory reactions, and guiding local tissue regeneration.

This study has developed a 3D-printed degradable biological mesh to better adapt to the shape of the prosthesis, exploring its application in breast prosthesis reconstruction, evaluating the impact of the degradable mesh on tissue regeneration, postoperative aesthetic outcomes, and postoperative complications, and establishing a new surgical model to fill domestic and international gaps.

The degradable personalized mesh provides a more personalized, physiological, and safe innovative technical option for breast reconstruction, promoting the implementation of precision medicine and regenerative medicine concepts in the field of breast cancer rehabilitation.

II. Study Objectives

Primary Objective: To evaluate the clinical efficacy and safety of 3D-printed degradable biological mesh for immediate prosthesis reconstruction after total mastectomy.

Secondary Objectives: To evaluate the quality of life and breast cancer-free interval of 3D-printed degradable biological mesh for immediate prosthesis reconstruction after total mastectomy.

III. Study Design

This study is a prospective, single-center, single-arm clinical trial. A total of 25 patients will be enrolled in this center. Enrollment will be non-randomized, with patients voluntarily participating in the study and signing a written informed consent form.

IV. Inclusion and Exclusion Criteria

1. Inclusion Criteria

a. Female breast cancer patients aged 18 to 70 years;

b. Histopathologically confirmed invasive breast cancer as defined by the latest ASCO/CAP guidelines;

c. Unable to undergo breast-conserving surgery or willing to undergo total mastectomy with breast prosthesis reconstruction;

d. ECOG performance status 0-1;

e. Subject voluntarily participates in this study and signs a written informed consent form.

2. Exclusion Criteria

a. Age > 70 years;

b. Newly diagnosed stage IV metastatic breast cancer;

c. Multicentric, extensive, diffuse lesions or inflammatory breast cancer;

d. Tumor invasion of the nipple-areola complex;

e. Unable to accept/tolerate radiotherapy;

f. Pregnancy-associated breast cancer;

g. History of other malignant tumors within the past 5 years, except cured carcinoma in situ of the cervix and non-melanoma skin cancer;

h. Abnormal function of important organs such as heart, lung, liver, kidney, poorly controlled diabetes, etc., unable to tolerate surgery;

i. Patients deemed unsuitable for participation in this study by the investigator.

V. Study Procedures

After fully informed and choosing the surgical method according to personal willingness, subjects will enter the trial period after passing screening. The specific research protocol is as follows:

1. Preoperatively, patients will complete the Chinese version of the BREAST-Q V2.0 scale to evaluate breast aesthetics, satisfaction, and quality of life.

2. Preoperatively, patients will undergo breast thin-slice magnetic resonance imaging, including conventional plain scan (SE T1WI sequence) and 3D dynamic contrast-enhanced scan (FLASH sequence), to obtain three-dimensional enhanced images.

3. Based on the three-dimensional magnetic resonance imaging results, a 3D-printed PCL

degradable biological mesh will be prepared (using medical polycaprolactone microspheres as materials, manufactured using a dedicated high-precision fused 3D printing platform, sterilized for later use, and provided free of charge by the Key Laboratory of Mechanical Manufacturing, Xi'an Jiaotong University).

4. Surgery: NSM and SSM breast reconstruction will be performed using 3D-printed degradable biological mesh combined with silicone prosthesis according to clinical routine.

5. Postoperative management: Dressing changes will be performed on time after surgery, and the occurrence of complications or adverse reactions such as infection will be recorded.

6. Postoperative systemic chemotherapy or endocrine therapy will be administered according to routine diagnosis and treatment. The decision to receive radiotherapy will be based on current clinical guidelines and standards.

7. Routine breast ultrasound examination will be performed weekly within 1 month after surgery, then once a month, and changes in the mesh on ultrasound images will be recorded. Breast ultrasound examination will be performed every 3 months after surgery. MRI examinations will be performed at 6 months, 12 months, and 24 months after surgery, and the Chinese version of the BREAST-Q V2.0 scale will be used to evaluate breast aesthetics, satisfaction, and
quality of life.

8. Database follow-up: Telephone follow-up once a month, and face-to-face follow-up once every 3 months.

VI. Risks and Discomforts

All surgeries may have side effects. If you experience any discomfort, new changes in your condition, or any unexpected situations during

the study, please inform your doctor promptly, who will make a judgment and provide medical treatment.

Postoperative complications:

1. Incisional infection: Simple incisional skin infection can be treated with careful dressing changes, and debridement and suture may be necessary if needed;

2. Hematoma: Dynamically observe the size of the hematoma, prefer local physical therapy and detumescence treatment; surgical evacuation of hematoma is performed if no improvement for a long time;

3. Upper limb numbness, upper limb edema, limited movement: These are common complications of breast cancer surgery. Patients are encouraged to exercise appropriately to improve local blood circulation and promote lymphatic return;

4. Local recurrence: Pathological examination of biopsy will confirm whether it is breast cancer recurrence. If it is local recurrence, the oncology department, breast surgery, radiotherapy department, and pathology department will be organized to consult and decide further treatment plans such as local extended resection or radiotherapy and chemotherapy;

5. Distant metastasis: Treatment plan will be determined in strict accordance with NCCN guidelines and expert consensus;

6. Incomplete degradation of the implant: If the implant is not completely degraded within 2 years or longer, you can request the attending doctor to remove the remaining filling material or choose to continue observation;

7. Capsular contracture of the breast after complete degradation of the implant: Depending on

the degree of contracture, clinical common remedial measures such as continued observation, surgical release, and fat injection filling will be selected.

You will need to come to the hospital for regular follow-up examinations during the study, which may cause inconvenience, but are very important for your health.

VII. Potential Benefits of Participation

In previous studies, our team developed a 3D-printed multi-layer porous mesh degradable PCL breast scaffold and found in basic research that this scaffold can provide stable support and has mechanical properties matching the breast. Animal studies have shown that this scaffold has excellent biocompatibility and creates an immune microenvironment conducive to local tissue repair and regeneration. In clinical trial results, not only was the world's first application of 3D-printed PCL scaffold in breast remodeling completed in 2017, but follow-up of 30 patients showed that the 3D- printed PCL scaffold has good tumor safety and meets the needs of breast remodeling after breast- conserving surgery. Therefore, based on previous research, this project has prepared a 3D-printed degradable biological mesh, which uses the same material as the previous scaffold and has been proven to integrate well with autologous tissue and achieve biodegradation in vivo without leaving foreign bodies or toxic substances. The mesh has better biocompatibility, is less likely to cause complications such as infection and capsular contracture, and reduces the risk of surgical complications and failure. As the mesh degrades in vivo, newly formed fibrous connective tissue,

fibroblasts, and blood vessels will fill the defect area, eventually replacing the implant with autologous tissue to achieve natural repair of breast tissue. Improving quality of life: The restoration of breast shape and reduction of complications help patients better accept their body image psychologically, enhance self-confidence, and become more active in social, work, and family life, improving overall quality of life. Patient participation will help clinically validate this new technology and provide a safer and more effective breast reconstruction option for more breast cancer patients in the future, promoting the development of personalized medicine and biodegradable material applications in the medical field.

VIII. Study Costs

Surgical costs include preoperative examinations, anesthesia, surgery, silicone prosthesis materials, etc., and will be charged according to Xijing Hospital's surgical standards without additional costs.

3D-printed degradable biological mesh will be provided free of charge.

There will be no compensation for follow-up visits and multiple postoperative breast examinations during the study.

IX. Study Compensation and Indemnification

No relevant economic compensation will be paid to you. In case of damage related to the trial, Xijing Hospital will pay you compensation in accordance with the law.

X. Alternative Therapies

Participation in this study is not mandatory for the treatment of your disease or condition. Other treatment options are available for your medical condition, such as silicone implant treatment. The benefits and

risks will be related to the specific treatment plan. You may achieve disease control or remission, but you may also experience some common toxic and side effects of treatment. Your research doctor will introduce you to the specific treatment plan and explain what good and bad situations may occur when accepting other treatment plans. He/She will answer all your questions.

XI. Confidentiality of Personal Information

Information collected in this study will be kept confidential in the hospital. To protect your identity, any information about you in research documents will use a uniformly formatted number instead of your name. In all collected and merged subject information, any information that can help identify you will be removed to ensure that the information cannot be linked to a specific research subject.

The ethics committee and regulatory authorities may directly access the subject';s original medical records to verify clinical trial procedures and/or data (the sponsor may not access) to the extent permitted by applicable laws and regulations and without violating the subject's privacy. By signing the informed consent form, you or your legal representative authorize such access. To the extent permitted by applicable laws and/or regulations, records identifying you will be kept confidential and will not be disclosed. The results of this study may be published in medical journals or shared for scientific purposes or used by the sponsor for product research or improvement, but your identity and personal information will never be disclosed.

XII. Withdrawal from the Study

During the study, the research doctor will consider your best interests. If it is deemed that you are no longer suitable to continue the trial (including disease recurrence, intolerable toxic reactions, and

serious adverse events), or if the sponsor/ethics committee/national government requires termination, the research doctor will proactively explain the reasons to you and terminate your participation in this drug study.

Your participation in this study is completely voluntary. You have the right to choose not to participate in this study and to withdraw at any time without penalty or loss of benefits, and your subsequent treatment will not be affected in any way. If you plan to withdraw from the study, please inform your research doctor promptly. For your safety, he will conduct a comprehensive examination and treatment for you. If the researcher obtains information that may affect your continued participation in the trial, you or your guardian will be notified promptly.

XIII. Contact Person and Contact Information

You can learn about information and research progress related to this study at any time. If there is new safety information related to this study, we will also notify you promptly. If you have questions related to this study, or if you experience any discomfort or injury during the study, or have questions about the rights of participants in this study, you can contact (Researcher: Zhang Juliang) at (Phone number: 13709224118).

XIV. Contact Information of the Ethics Committee

If you have any questions or appeals regarding the rights and health of participating in this study, you can contact the Ethics Committee of Xijing Hospital, contact number: 029-84771794.

Subject Informed Consent Signature Page

I have read the above informed consent form in detail and understand the purpose of the study and the possible benefits and risks of participating in the study. The researcher has clearly explained the above medical terms. I have had the opportunity to ask questions and all questions have been answered in an understandable manner. I may choose not to participate in this study or withdraw after notifying the responsible doctor at any time, and my medical treatment and rights will not be affected. If I need other treatments, or if I do not comply with the research plan, or if I suffer injury related to the research, or for any other reason, the responsible doctor may terminate my continued participation in this study.

I have read the above informed consent form and received a copy, and my doctor has also given me a detailed explanation. I voluntarily participate in this clinical trial.

Subject's Name in Block Letters: _____

Subject's Phone Number: _____

Subject's Signature: _____

Date: (Year/Month/Day)： _____

*(***Note: If the subject has no capacity for civil conduct, the guardian's signature is required; if the subject has limited capacity for civil conduct, both the subject and his/her guardian need to sign***)*

Guardian's Name in Block Letters： _____

Relationship with Subject: _____

Guardian's Signature: _____

Guardian's Phone Number: _____

Date: (Year/Month/Day) _____

Witness's Signature (if applicable): _____

Date: (Year/Month/Day) _____

(If the subject or his/her guardian is illiterate, an impartial witness is required to sign. The impartial witness will read the informed consent form and other written materials and witness the informed consent.)

I confirm that I have fully explained the relevant content of this clinical trial to the patient, including the possible benefits and risks, and answered all questions raised by the patient.

Investigator's Signature (in block letters): _____

Date: (Year/Month/Day) _____

Investigator's Phone Number: _____

Date: (Year/Month/Day) _____