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Proposal of Spot Compression Method using 3D Print for Mammography

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Abstract

Background/Objectives: The purpose of this study is to propose a new imaging method using an assistive device manufactured using a 3D printer in partial compression imaging for the separation of tumor and surrounding tissue during mammography.

Methods/Statistical analysis: The clinically used partial compression imaging method uses a method of changing the upper compression paddle to the partial compression paddle in the conventional imaging method, marking the area to be compressed, and then pressing. At this time, I would like to suggest a new partial compression band method to solve the change time and inconvenience. This method does not replace the existing compression rod, but instead is used by placing the compression rod under the lesion area and pressing it with the compression rod above it.

Findings: Modeling 1 and Modeling 2 were printed by dividing layers and having different sizes for each layer, and Modeling 3 was produced in a spherical shape.

Improvements/Applications: The applicability of the new examination method was confirmed according to the compression band in the breast area. In addition, this study is expected to serve as basic data for more diverse clinical applications in mammography.

Keywords: Spot compression, Mammography, 3D Printer, Resin, breast

1. Introduction

For adult women, breast cancer is an unsafe disease. In fact, the cancer disease with the highest incidence among Korean women is breast cancer, and the incidence rate is increasing rapidly every year[1]. The causes of this are various factors such as the westernized diet of modern people and the resulting obesity, old marriage and low birth rate, and avoidance of lactation. Therefore, the frequency of female mammography examinations for early diagnosis of breast diseases and the need for photographing are also increasing[1,2].

When compression is applied during mammography, the patient's pain accompanies, but by minimizing the thickness of the breast, the breast tissues can be further subdivided. In particular, when partial pressure is applied to the area to be observed for the lesion, the breast tissue is distributed more evenly, so the contrast is improved and the image clarity is increased[3,4]. At this time, the compression paddle used should have excellent radiation penetration, and the image quality and the dose received by the patient should be considered by adding additional radiation according to the thickness of the compression table[5,6,7].

The partial compression paddle currently used in clinical practice is used according to the shape of the basic compression paddle[8,9]. The pressure and thickness of the press, which is being studied in Korea to complement this press, are highly emphasized. However, when viewed from a different point of view, such as a radiologist taking a breast, replacing the compression paddle each time in the middle of the imaging can cause a long time and inconvenience to the patient. In order to compensate for these shortcomings and minimize discomfort, it is necessary to study new design pressure paddle such as shape, size, and thickness, unlike before. On the contrary, the new compression paddle proposed in this paper aims to shorten the time and improve the efficiency of the examination by placing the partial compression paddle under the breast, unlike the conventional imaging method. Therefore, new compression imaging tools are developed and applied to further increase the value of breast compression imaging. In this study, we tried to confirm that the same or more improved image quality will appear in a different way than before.

2. Materials and Methods

2.1. Materials

2.1.1 3D Printer

If the shape of the compression rod becomes uneven during 3D printing, artifacts may occur in the image and may be mistaken for a tumor. With this in mind, you should design a flat and even density. In addition, during printing, the surface of the upper part of the compression bar that the breast touches is rough, so that even density cannot be maintained. To compensate for this, the presser must be rotated and adjusted to create a rough surface on the side rather than the upper end.

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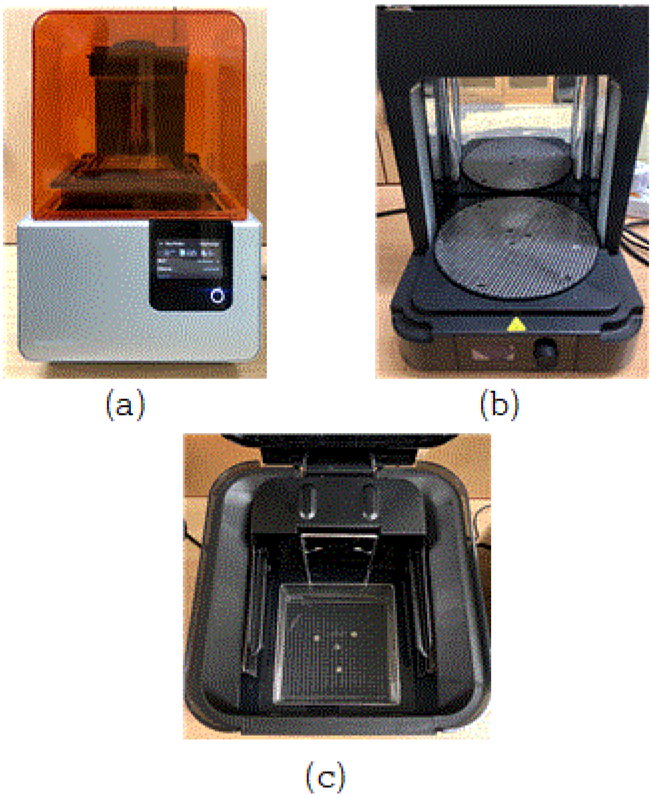


Figure 1.(s) 3D Printer(L.Corporation, Form2, SLA) (b) Curing machine (c) Washing machine

2.1.1 New spot compression device

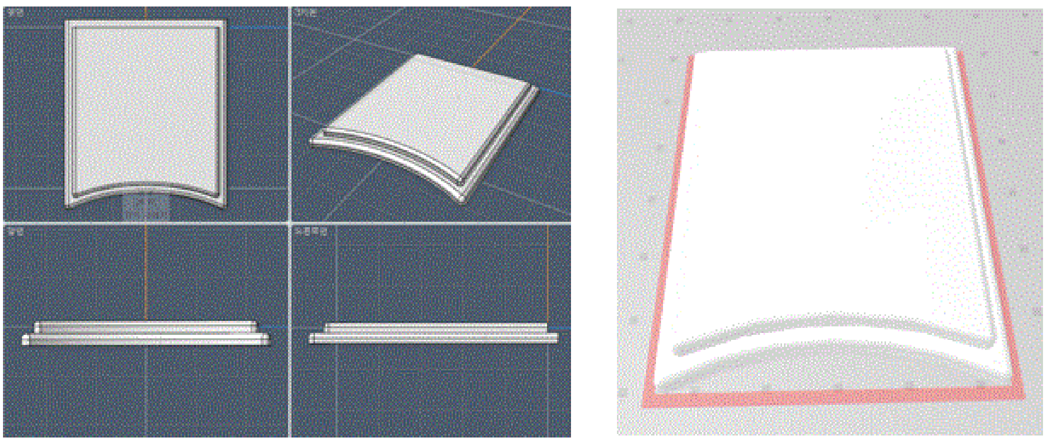
Breast examination is a method for early detection of breast cancer, and it is essential to detect microcalcifications that are not visible on ultrasound. Partial compression imaging during breast examination is a method to show the lesion more clearly by separating the lesion from the normal breast tissue by partially compressing the tumor to be touched or the lesion seen in the image.

Currently, the clinically used partial compression imaging method uses a method of changing the upper compression paddle to the partial compression paddle in the conventional imaging method, marking the area to be compressed, and then pressing. At this time, I would like to suggest a new partial compression band method to solve the change time and inconvenience. This method does not replace the existing compression rod, but instead is used by placing the compression rod under the lesion area and pressing it with the compression rod above it. The new method has the advantages of time reduction and convenience.

If the shape of the compression rod becomes uneven during 3D printing, artifacts may occur in the image and may be mistaken for a tumor. With this in mind, you should design a flat and even density. In addition, during printing, the surface of the upper part of the compression bar that the breast touches is rough, so that even density cannot be maintained. To compensate for this, the presser must be rotated and adjusted to create a rough surface on the side rather than the upper end.

2.2. *Methods*

2.2.1. Modeling 1



(a) (b)

Figure 2. (a) before printing image (b) new spot compression device modeling 1

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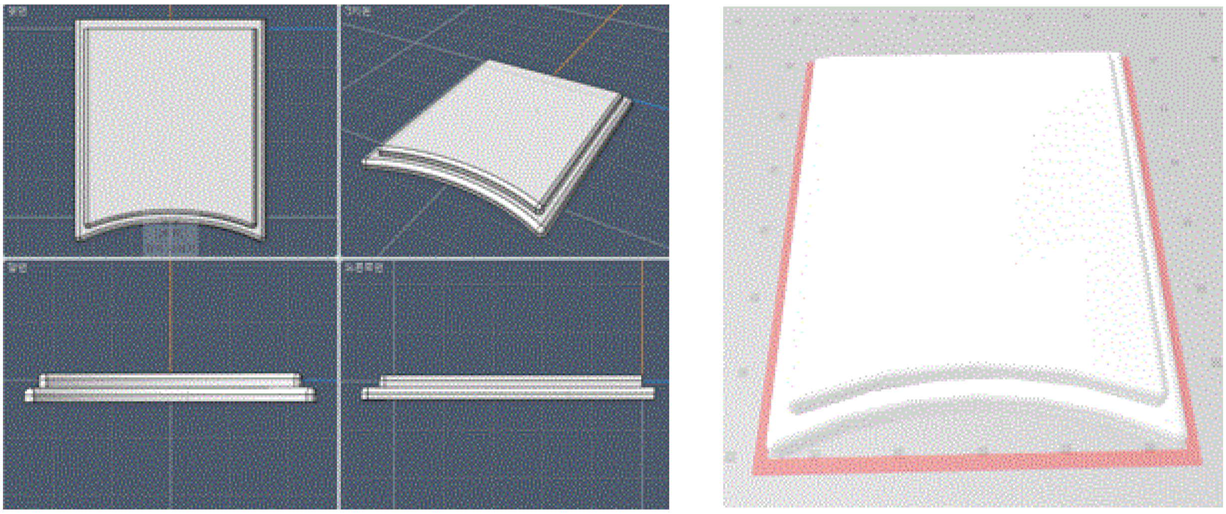
As shown in Fig 2, the upper pressurizes a sense of stability when pressing through the same rectangular design as the existing presser, which is a rectangular shape. It is designed in a shape that is suitable for placing the breast on the compression table and a convenient shape with an arc in the area where the breast touches in a rectangular shape. Since the patient may feel pain due to the arc-shaped corners, 'hair picking' was performed to transform the corners into a rounded shape.

In order to bring more effective partial compression efficiency than when pressing with one layer of compression, the area of the upper layer was set smaller than that of the lower layer by stacking two layers. The thickness was set to 0.5cm per layer and a total of 1cm.

2.2.2. Modeling 2



(a) (b)

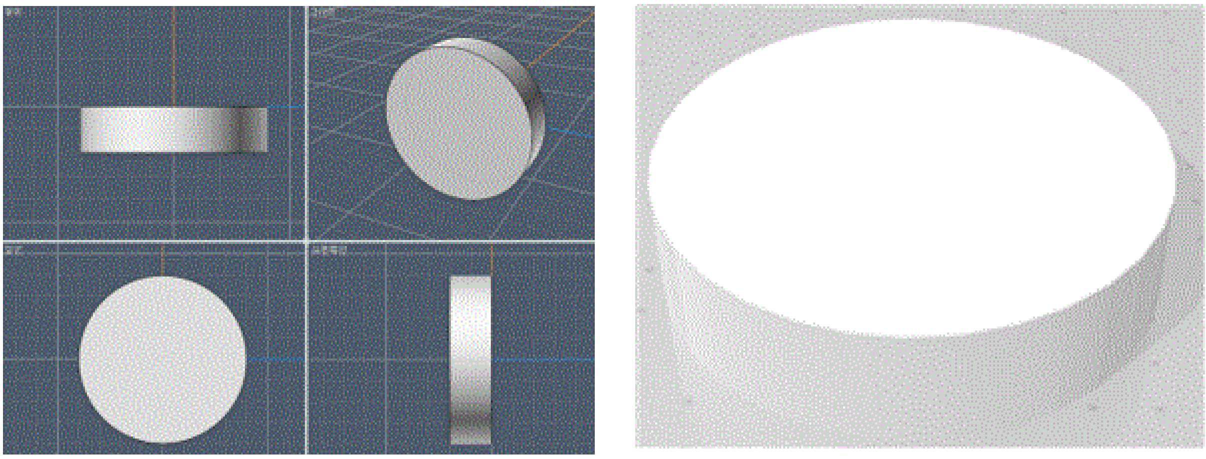
Figure 3. (a) before printing image (b) new spot compression device modeling 2

As shown in Fig 3, modeling 1 was found to be relatively large compared to the breast size of Korean women. As a result of the survey by the Korean Human Body Index (Size Korea), the average breast width of Korean women (20 to 59 years old) after their 20s was estimated to be about 28 cm, which is about 14 cm per breast. Considering that the average dimension is 14 cm and the partial compression paddle, the width was set to 5 cm.

Since there is a possibility that the area of the protruding part of the pressurizing table on the first floor may not be pressed, the protrusion of the arc-shaped part was set to be the same.

This design makes it possible to move the compression stand and the breast surface as closely as possible, so it is convenient to move in multiple directions, so that the shooting can proceed smoothly. In addition, it is expected that the thickness is higher than that of other modeling, so that the compression is better and the results are effective in observing the lesion.

2.2.3. Modeling 3



(a) (b)

Figure 4. (a) before printing image (b) new spot compression device modeling 3

As shown in Fig 4, If there is a height in the compression bar, if the thickness is partially changed, it cannot have a uniform concentration value. At this time, it was designed in the shape of an existing partial compression paddle in consideration that errors

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may occur in classifying the lesion. In addition, since it is placed under the breast and photographed, it was designed in a round, round shape without an angle in consideration of the patient's pain when the compression table is in an angled shape.

When the degree of compression of the breast varies depending on the thickness of the compression paddle, the shape of the lesion is revealed differently in the image. Therefore, in order to obtain the most distinguishable conditions in the image, the thickness of the compressed breasts of Korean women was 3.8cm on average, and the design was made to be 2cm thick. In Modeling 2, unlike the material in Modeling 1, Flexible Lesin was used. Flexible Lesin is more flexible than existing Lesin, so it can alleviate patient pain.

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3. Results

3.1. new spot compression device

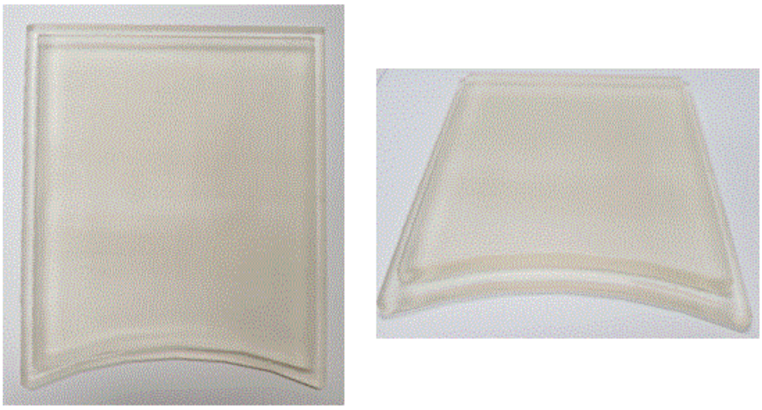
As shown in Fig 5 and 6, modeling 1 and Modeling 2 were printed by dividing layers and having different sizes for each layer, and as shown in Fig 7, modeling 3 was produced in a spherical shape.

The size of the lower part of Modeling 1 was printed as 12.7x15.24cm. The size of the upper part was set to 10x11cm, and the total thickness of the upper part and the lower part was set to 1cm at 0.5cm per layer.

The standard of the lower part of Modeling 2 was set to 5x6cm and the upper part was set to 4x5cm. These values were determined by considering the average breast size of women. In addition, the thickness of Modeling 2 was set to be thicker than Modeling 1 so that the lower part was 1.5 cm and the upper part was 1 cm.

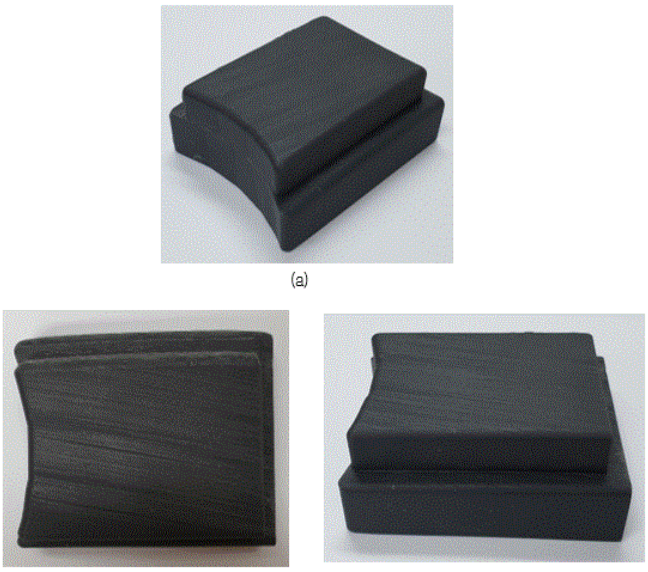
The standard of Modeling 3 is 8x8cm and the thickness is set to 2cm.

The time required for printing was 10 hours for modeling 1, 11 hours for modeling 2, and time for modeling 3. After printing, all were washed in a washing machine for 20 minutes, and then cured in a curing machine for 20 minutes to finish.



(a) (b)

Figure 5. Modeling 1 printing. (a) upper image (b) side image



(a) (b) (c)

Figure 6. Modeling 2 printing. (a) oblique image (b) upper image (c) side image

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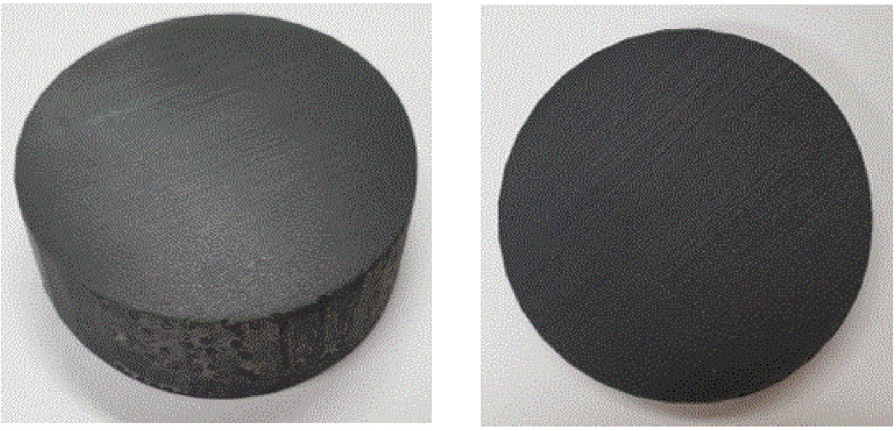

(a) (b)

Figure 7. Modeling 3 printing. (a) oblique image (b) upper image

4. Discussion

Breast examination is an important examination when diagnosing breast cancer, and it is currently being practiced in many cases as the incidence of breast cancer is increasing[10,11]. In this paper, a new compression paddle was devised for the convenience and time reduction of partial breast compression imaging.

In consideration of some problems when manufacturing the compression rod, it was designed so that the image was not affected by the compression rod[11,12]. With this in mind, when printing the press, the support is set to be formed on the side surface that does not touch the body surface, not the compression surface. Contrary to expectations, some supports were formed on the surface, and because of this, the density and flatness are not perfect, so there may be a difference in the image.

The thickness of the breast should be made thin for the reduction of the exposure dose and excellent image quality[13]. However, it is accompanied by a lot of pain. The thickness of the compression bar of modeling 1 is 1cm, which is thinner than the compression bar of modeling 2 and modeling 3, so a similar effect occurs when the breast is pressed more strongly. Taking this into account, you should choose an appropriate thickness for the compression bar.

If the compression band is too large or too small than the tumor, it is not suitable for partial breast compression. In addition, the size of the breast varies from person to person, so it is necessary to set the size of the compression paddle in consideration of this point.

It is expected that the use of a new compression paddle taking this into account will help reduce the time and convenience of partial breast compression imaging.

5. Conclusion

This study was conducted to devise a more efficient test method, such as reduction of patient pain, convenience of test method, and reduction of test time during conventional breast compression imaging. A new presser was designed according to various shapes, thicknesses, and sizes and printed with a 3D printer.

Among the existing 3D printing methods, the FDM method was excluded because it could not show an even distribution pattern at the time of radiographic transmission, and the SLA method was adopted to make a shape by hardening with resin. It was considered that it would not affect breast tissue and disease in radiographic images because it showed an even density distribution inside during printing.

As a result, the applicability of the new examination method was confirmed according to the compression band in the breast area. In addition, this study is expected to serve as basic data for more diverse clinical applications in mammography.

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