



Design And Construction Of Fixation Device On Babygram Examination At Dr Gunawan Mangunkusumo Hospital

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ABSTRACT

Abstract: Babygram examination is a radiographic procedure used to assess the thoracic to abdominal regions of newborns. The main challenge in this examination is the infant's spontaneous movements, which are difficult to control. As a result, radiographers often involve family members to restrain the infant's body. This practice increases the risk of secondary radiation exposure and does not comply with the ALARA (As Low As Reasonably Achievable) principle of radiation protection. Therefore, a fixation device that is safe, comfortable, radiolucent, and capable of maintaining the infant's position without involving family members is needed. **Methods:** This study aims to design and evaluate the feasibility of a fixation device for babygram examinations at RSUD (Regional General Hospital) dr. Gunawan Mangunkusumo. It employed a Research and Development (R&D) approach with a limited testing stage based on the Sugiyono model, which included problem identification, literature review, device design, design validation, revision, and limited trials. The device was developed using soft foam, fabric, and body straps, selected for their radiolucent properties and comfort for pediatric patients. Testing was conducted by six expert respondents, consisting of five experienced radiographers and one radiology specialist. A Likert-scale questionnaire was used to assess functionality, stability, ease of use, comfort, and the potential for image artifacts. **Results:** The results show that the fixation device achieves an average score of 4.4 in the functional evaluation, indicating that the device functions very well, is easy to handle, comfortable to use, and does not produce artifacts on radiographic images. In the performance evaluation, the device also receives an average score of 4.4, demonstrating its effectiveness in assisting radiographers with patient positioning and improving the stability of the infant's body during the examination. In addition, the device reduces the need for family involvement, thereby enhancing safety by minimizing radiation exposure. **Conclusion:** In conclusion, the developed babygram fixation device is deemed suitable for use in pediatric radiological examinations. The device improves examination quality, enhances patient comfort, and supports better implementation of radiation protection principles in the clinical setting.

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1. INTRODUCTION

The development of science and technology in the health sector has made a great contribution to improving the quality of medical services, especially in the aspect of diagnosis through radiological examination. Radiology is now one of the important components in the diagnosis enforcement process because it is able to provide a



noninvasive and accurate picture of the anatomy and physiology of the body (Lampignano & Kendrick, 2020). Radiological examinations are not only needed for adult patients, but also have an important role in children's health services, including newborns. The physiological and anatomical characteristics of child patients who are still in the growth stage cause radiological examinations in this population to require special attention, both in terms of radiation dose, comfort, and *patient* safety (Long, Rollins, & Smith, 2015).

Radiology is a science that studies the process of making images (radiography) and human organs using X-ray radiation as a source of image recorder. In radiology examinations, the results of the images will be very helpful in diagnosing a disease suffered by humans (Angella et al., 2020). Radiological examinations are divided into two types, namely conventional radiology and imaging radiology. One form of conventional radiological examination that is carried out without the use of contrast media is *babygram* (Rumah et al., 2024).

Babygram is a radiological examination in infants that will produce a radiographic image from the thorax to the pubic symphysis (Meutia et al., 2018). This examination is generally performed on newborns with clinical indications such as respiratory distress, abdominal distension, or suspected bone abnormalities. Based on data from the Department of Radiology of Dr. Soetomo Surabaya Hospital (2022), there are an average of 45–60 *babygram* examinations

Per month, this number continues to increase as the birth rate increases. In practice, this examination often faces obstacles in the form of baby movements that are difficult to control, so radiographers often ask for the patient's family to help hold the baby during irradiation. This condition increases the risk of radiation exposure for the patient's family, so a fixation aid is needed to keep the patient's position stable without posing additional risks.

"And do not throw yourselves into destruction..." (QS. Al-Baqarah: 195)

This paragraph reminds the importance of efforts to maintain human safety, including in the practice of health services. In the context of radiological examinations, the safety of patients and their families is the top priority that must be considered.

One of the actions to distance oneself from destruction is to minimize the increased risk of radiation exposure during radiological examinations, especially in *babygram* examinations, namely by using radiography examination aids so that the public, officers, and patients' families avoid secondary X-ray radiation during the examination. The existence of examination aids is very necessary in *babygram* examinations. Fixation tools are a tool that can help patients feel comfortable so as to support the course of the examination (Long et al., 2015). These aids aim to help the radiographer's performance when positioning patients, especially in pediatric patients. In addition, it is necessary to pay attention to the use of fixation tools and materials used in the manufacture of fixation tools, where the fixation tools used do not interfere with the radiograph results and still prioritize the patient's comfort without interfering with the radiograph results, so that the improvement in the examination gets a minimal risk of radiation exposure, and gets optimal radiograph results. Wide range of tools

Help with examinations in the world of radiology, including *cassette holders, tam-em boards, sponges and soft bags, pig-g-o-stat, compression band* (Lampignano & Kendrick, 2020).

According to Long et al. (2016), *babygram* examinations generally use *Posterior* (AP) and *Lateral Antero* projections. The same thing is also expressed by Smith (2016), who stated that AP and *Lateral* projection are standard techniques in this examination. One of the journals that the authors reviewed also added that the use of *lateral* projection in *neonates* is useful for showing air accumulation, which usually appears to rise and accumulate in the *lateral area* of the chest (Henry Knipe, 2019).

Based on observations, it is known that dr Gunawan Mangunkusumo Hospital has many requests for *babygram* photos. *Babygram* examination is carried out using *Posterior Antero* (AP) projection. *Babygram* examinations often have obstacles including positioning the patient, the patient often moves during the examination so that often the patient's family helps hold the patient to minimize movement in the patient, and often also the patient's family is exposed to radiation during the *babygram* examination, the existence of a device assisted fixation also contributes to the application of the ALARA (*As Low As Reasonably Achievable*) principle in radiation protection, by reducing the direct involvement of unprotected families or staff in the exposure zone, therefore it is necessary to design fixation devices to minimize movement in patients.

Previous research in Indonesia is generally still limited to fixation devices for examination of the child's limbs or thorax which are manual in nature and have not considered ergonomic aspects and radioluscent materials (Iskandar et al., 2020). Therefore, this study offers innovations in the form of *babygram* fixation devices based on soft foam and adhesive fabrics designed according to the baby's anatomy, it is lightweight, safe, and does not cause artifacts in radiographic images. This innovation is expected to be an alternative to local fixation aids that are affordable, effective, and in accordance with the conditions of health facilities in Indonesia

Based on this description, this study was conducted to answer the need for a fixation device that is simple, safe, and in accordance with the characteristics of infant patients in Indonesia. The purpose of this study is to design and

evaluate a prototype of a fixation device for infant patients on babygram examinations, which functions to maintain the stability of the patient's position, improve the quality of radiographic images, and reduce the risk of radiation exposure to the patient's family. Through functional and performance testing, this research is expected to produce a fixation device that is suitable for use in pediatric radiology examinations and can be an effective and economical alternative to local fixation aid innovation.

Therefore, the researcher is interested in studying further in a Scientific Paper entitled "Design and Construction of Fixation Tools on Babygram Examination".

LITERATURE REVIEW

A. Radiogy Examination

Radiology is a science that studies the process of making images (imaging) of human organs using X-ray radiation as an image recorder. Radiology has a very important role in the field of medicine and the field of health services. Radiodiagnostics is a health service to perform diagnostics and provide therapy using ionizing radiation, one of which is a conventional radiology service (Rahmawati & Hartono, 2021).

B. Babygram Examination

A babygram is a radiological examination of the baby who is about to produce radiographic images from the thorax to Symphysis Pubis (Meutia et al., 2018). Diagnostic X-rays are carried out to obtain an image of a body object and diagnose diseases in newborns such as Neonatal Sepsis where the patient has abnormalities in the respiratory system and requires a breathing apparatus to manage the airway (Yunus et al., 2019).

C. Anatomy

1. Thorax

The thoracic skeleton is part of the skeletal system that functions as a protective structure as well as a framework for important organs involved in the respiratory and circulatory systems. The term viscera thoracic refers to the organs located in the chest cavity, including the lungs and other organs located in the mediastinum. Externally, the thoracic consists of the sternum, which is divided into three parts. At the top, there are two collarbones (clavicles) that connect the sternum to other skeletal structures (Budhyanti, 2020).

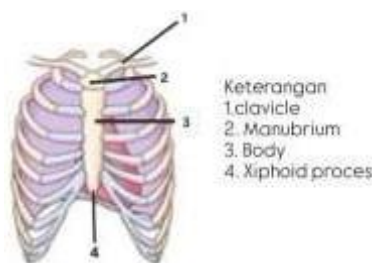


Figure 1. Thorax Anatomy (Lampignano & Kendrick, 2020)

2. Shoulder blades 12 pairs of ribs that surround the chest and 12 posterior thorax vertebrae

The lungs are elastic, cone-shaped, and are located in the chest cavity. The central mediastinum containing the heart and several large blood vessels separate the lungs. Each lung has apex (upper part of the lung) and base. Pulmonary and bronchial blood vessels, bronchi, nerves and lymph vessels enter each chest lung hilus and form a larger right lung alveolus which is divided into three lobes by an interlobar fissure. While the left lung is only divided into two lobes (Drake et al., 2019).

The lobes are further divided into segments according to their bronchial segments. The right lung is divided into ten segments and the left lung is divided into nine. Pathological processes such as atelectasis and pneumonia are often limited to only one lobe and one segment. A continuous thin layer containing collagen and elastic tissue, often referred to as the pleura (Drake et al., 2019).

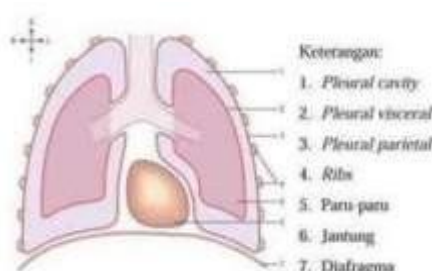


Figure 2. Anatomy of the pleura (Lampignano & Kendrick, 2020)

The pleura consists of two layers, namely the *parietalis pleura* that lines the walls of the chest cavity and the *visceralis pleura* that covers the surface of the lungs. Between these two layers there is a thin layer of *pleural fluid* that serves to reduce friction when the lungs move during the breathing process and keep the lungs attached to the thoracic wall.

This condition can be likened to two glass plates of objects that stick together because of the presence of water between them that are easy to move with each other, but difficult to separate. The air pressure in the pleural cavity is lower compared to the pressure of outside air (atmosphere), thus helping to prevent the lungs from deflating. However, if the pleura experiences disorders such as inflammation or the ingress of air/fluid, then the lungs can be depressed to the point of collapse (Budhyanti, 2020)

D. Examination Fixation Tool

According to Long et al., 2015 fixation devices are special aids used to reduce the movement of objects, increase patient comfort and make the radiographer's work easier so that they can produce optimal radiography, so that they will produce optimal radiography. There are various types of fixation devices used in radiography examination, including leg support and *film holde*, *tam-em-board*, *sponges*, *sandbags*, *pigg-o-stat*, adhesive (*tape*), *child immobilizer on lateral projection* (Lampignano & Kendrick, 2018) and *caliper* (Long et al., 2015).

1. Leg support and film holder

Used for patients with *bilateral merchant projection patella* examination as a leg restraint and cassette holder (Lampignano & Kendrick, 2020)



Gambar 3. Leg support and film holder
(Lampignano & Kendrick, 2020)

2. Tam-in Board

Tam-em Board is an examination fixation device with several fastening belts that are used to maintain the movement of pediatric patients. This fixation device is used to lateral head examination in infants (Lampignano & Kendrick, 2020).



Figure 4. Tam-em Board (Lampignano & Kendrick, 2020)

3. Sponges and sandbags

In general, the use of sponges is used by pediatric patients and adult patients as a fixation tool. The reason for the use of sponges and sandbags is because the risk of artifacts occurring on the radiograph is so small.



Figure 5. *Sponges* (Lampignano & Kendrick, 2020)

4. *Pigg-O-stat*
Pigg-O-Stat constitute Immobilization Tool The digunakan for inspection Radiographs Chest and Abdominal in infants and children under 5 years of age (Lampignano & Kendrick, 2020)



Figure 6. *Pigg-O-Stat* (Lampignano & Kendrick, 2020)

5. *Adhesive (tape)*
The use of adhesives to reduce movement, especially in pediatric patients (Lampignano & Kendrick, 2020)



Figure 7. *Adhesive (tape)* (Lampignano & Kendrick, 2020)

6. *Child Immobilizer On Lateral Chest*
Tools fixation of this
Use it on lateral thorax examination of pediatric patients. The patient is positioned supine with a fixation device under the patient's body (Lampignano & Kendrick, 2020).



Gambar 8. Child Immobilizer On Lateral Chest (Lampignano & Kendrick, 2020)

7. Caliper

This device is used to measure the thickness of body parts to ensure that accurate and consistent exposure factors are used. Calipers are also used to hold a 10 x 15 inch (24 x 30 cm) grid for *lateral radiography of the cervilacal spine* (Long et al., 2015).

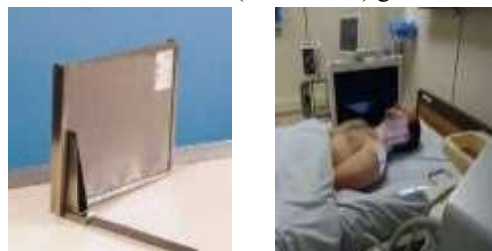


Figure 9. Caliper for lateral radiography examination of cerfical spine (Long et al., 2015)

METHOD

This research is a Limited Experimental research with a *Research and Development* (R&D) approach. The R&D approach was chosen with the main objective of producing a prototype of a fixation device product and testing its functional feasibility and performance in a clinical environment. The R&D model used as a reference is the Sugiyono Model (2018). This model consists of ten stages, but this study only carries out the first six stages, namely: (1) Potential and Problem, (2) Data Collection (Literature Study), (3) Product Design, (4) Design Validation by Experts,

(5) Design Revision, and (6) Product Testing (Function Test and Performance Test). This study is categorized as Limited Testing Without a Comparison Group, because it is focused on the functional validation of locally designed tools and there is no similar standard tool for pure experimental comparison.

The prototype fixation device was designed specifically for the examination of Posterior Antero (AP) projection babygram in infant patients. The materials used, such as solid foam and non-metallic fabrics, were chosen for their radioluscent properties to minimize the risk of artifacts on radiographic images, while still ensuring patient comfort and safety. This fixation device is in the form of a small, stable mattress and consists of seven main fixation components that work synergistically (See Figure 3.1): (1) Fixation Tool Base as the main base and cassette stand; (2) Pillow for

supporting the head to neutral; (3) Upper Extremity Adhesive (if possible), 3 which functions to fix the wrist in an upward extension position, clinically important to free the lung field from superimposed arm bones; (4) Lower Extremity Adhesive which fixates the leg to prevent pelvic rotation; and (5) Body Strap which is the main restraint of the baby's torso from moving during radiation exposure.

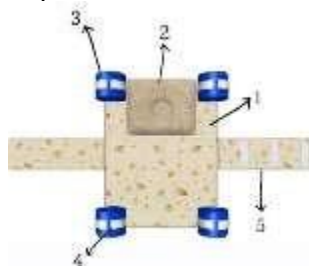


Figure 10. Design and Construction of Babygram Fixation Device (dr Gunawan Mangunkusumo Hospital, 2025)

Description:

1. Wings Tools fixation Babygram Examination
2. Pillow
3. Top extermite adhesive
4. Bottom Thermity Adhesive
5. *Body strap*

The subjects used in the test were infants, The tool trial was carried out on 6 (six) respondents who were selected purposively for a limited trial. The composition of respondents was selected from different backgrounds for the triangulation of the assessment, namely 5 (five) Radiographers of Dr. Gunawan Mangunkusumo Hospital with more than 10 (ten) years of work experience, and 1 (one) radiology dr. with more than 2 (two) years of work experience at Dr. Gunawan Mangunkusumo Hospital, 6 (six) respondents were selected to assess the ergonomic and methodological aspects of the fabrication tools that had been made.

The data collection instrument is a Checklist Questionnaire consisting of 8 (eight) assessment items using a 5-point Likert Scale (1=Strongly Disagree to 5=Strongly Agree). This questionnaire is divided into two parameters

Main: Function Test (5 items) which assesses technical feasibility and safety, and Performance Test (3 items) which assesses clinical efficiency in assisting the radiography process. The instrument has passed the content validity test through expert judgment by the supervisor and radiologists to ensure the relevance of the question items to the pediatric fixation standard.

The data obtained from the respondents' questionnaire was analyzed in a quantitative descriptive manner by calculating *the Mean Score* of all indicators. The average result of this score will then be converted into the eligibility criteria of the fixation tool based on a maximum scale of 5, according to the standardized feasibility interpretation table in R&D research. This analysis method ensures that the conclusions drawn regarding the feasibility of the tool are based on objective and measurable calculations.

RESULTS

A. Results of Fixation Device Design

Babygram

At this stage, it covers the tools and materials used, the manufacturing process, and how the fixation tool works.

1. Tools and materials used
 - a. Fabric
 - b. Adhesive
 - c. And so it is
 - d. Sewing needles
 - e. Yarn
 - f. Restraint strap
 - g. Scissors
2. Manufacturing process

Here's how to make a fixation tool: The steps to make a fixation tool frame start from measuring foam with a size of 35 x 43 to adjust it to the design of the fixation tool.



Figure 11. Foam baby mattress covered with fine fabric (dr Gunawan Mangunkusumo Hospital, 2025)



.....
 Cut a soft cotton cloth according to the baby's body size (approx. 40–50 cm square) Sew the sides, Sew a small pillow from a soft fabric Place the pillow on the top of the base and sew them together.



Figure 12. Foam baby mattress with *restraint strap* added (dr Gunawan Mangunkusumo Hospital, 2025)

The *restraint strap* is placed in a predetermined position on the side of the main base (near the head pillow), adjusted to the baby's body size so that it can support the hands/feet appropriately The position of the end of the roll is neat and flattened so that the seam looks neat and firmly attached to the base The stitching is done carefully, ensuring that the blue fabric (support) is tightly attached to the patterned base. The seams are reinforced at the ends and middle so that the rolls do not come off easily when used After the sewing process is complete, a re-check is carried out to ensure The stitches are strong, neat, and do not hurt the baby.



Figure 13. Foam baby mattress with adhesive on the bottom of both sides of the *bodystrap* (dr Gunawan Mangunkusumo Hospital, 2025)

The adhesive is cut to the required length using scissors. The length of the adhesive must be adjusted so that it is sufficient to circle the support roll and can be firmly glued. After cutting, the adhesive is placed on the center side of the adhesive body strap carefully sewn using strong threads, running along the edges of the adhesive to adhere tightly. The stitching can be done with a sewing machine.



Figure 14. *Bodystrap* covered with fine fabric. (Dr. Gunawan Mangunkusumo Hospital, 2025)

.....
Add body straps on the left and right sides for baby body support.

3. How Fixation Tools Work

How the Babygram Fixation Tool works is not so complicated, the steps of the tool are as follows:

- a. For *Anteroposterior* (AP) projection, place the tape under the mattress then position the patient in a supine position on a comfortable mattress set the baby's position straight, hands up use upper extremity adhesive if needed, both legs are glued to the lower extremity adhesive and body step to support the baby's body so that it does not move easily.



Figure 15. Results of *Babygram Examination Aids* (dr Gunawan Mangunkusumo Hospital, 2025)



Figure 16. Positioning the Baby on the Anteroposterior Projection (dr Gunawan Mangunkusumo Hospital, 2025)



Figure 17. Results of Anteroposterior Projection Radiography (dr Gunawan Mangunkusumo Hospital, 2025)

2 Test results of the Babygram fixation tool Results Testing fixation obtained through the stages of performance tests and function tests. Performance tests and function tests were carried out by answering checklist sheets to 6 (Six) expert respondents, consisting of Radiographers, and Radiology Specialists.

The results of the fixation test were obtained through the performance test and function test stages. Performance test and function test by answering a checklist sheet to the radiographer.;;



a. Test the function of the Fixation Device for babygram examination, the procedure for using a fixation device in the babygram examination with the direction of the beam perpendicular to the cassette, begins by placing the tape under the fixation device after the tape is placed, adjust the position of the supine patient on the hand fixation device is directed upwards using upper extremity adhesive if needed then use a body strap to support the patient's body to reduce movement during the examination then both legs are glued using lower extremity adhesive.

The evaluation of the tool was carried out through the distribution of a questionnaire containing eight statements to 6 (six) expert respondents, consisting of five radiographers experienced in radiological examinations and one radiology specialist. This instrument was used to assess aspects of function, ease of use, stability of the tool, and patient comfort in babygram examination with the direction of the beam perpendicular to the tape.

The development of questionnaire items is based on theories regarding the function of fixation devices and the principle of pediatric patient comfort from Long, Rollins, & Smith (2015) and Lampignano & Kendrick (2020). Both sources explain that pediatric radiography fixation devices function to reduce patient movement, improve safety, and help radiographers obtain optimal imagery without causing artifacts.

Because this study is an R&D research limited testing stage at the Diploma Three level, the validity and reliability testing of statistics has not been carried out in a systematic manner

Table 1. Recapitulation of Assessment Questionnaire Results

Fixation Tool Eligibility

Formal. Instead, content validity is confirmed through expert judgment by Function Test						R1	R2	R3	R4	R5	Dr .		
2	Cashew	and the bearings can				1	Adhesives and	5	4	5	5	4	4
Functional													
5	4	5	5	5	4								
radiology specialists and four senior radiographers, to ensure the suitability of each question item with the theoretical concept of fixation tools													
well													
3	Tools	fixation	4	4	5	4	4	5	Easy				
Moved													
pediatrik.													
According to Sugiyono (2018), in													
4	Busa												
Comfortable object handler													
4	4	5	5	5	4								
Early-stage R&D research, trials													
digunakan													
Instruments should done in limited quantities, and the results are considered valid													
5	Tools	Fiction	does not	give rise to									
5	4	4	5	4	4								
when it has gone through a member assessment													
and show logical consistency between question items. Therefore, the use of six expert respondents in this study is nsidered representative enough to assess the functional feasibility and ergonomics of the tool before conducting ger-scale testing (field testing).													
The results of the assessment from the six respondents were then used to determine the feasibility and potential plication of the fixation device on the babygram examination in a clinical setting													
artefak						Quantity	23	20	24				
24	22	21											
Total 134													

The results of the calculation of the success rate of the fixation tool function test are calculated by the formula:
Percentage of success rate Description:

- 1= Disagree
- 2= Disagree
- 3= Agree enough
- 4= Setuju
- 5= Strongly Agree



Then the recap data of the results of the function test and the results of the fixation performance test are calculated according to the formula that has been determined in the previous chapter as follows:

Nilai Skor total Kuesioner

Total working value =

Responden x Jumlah pertanyaan

= 134 = 4.4

30

Based on the calculation of the recap of the function test results of the fixation device, the total working value of 4.4 was obtained. Therefore, it can be concluded that the babygram fixation device has a very good function, and the fixation device does not cause artifacts.

b. Test Tools	Performance Fixation of babygram	Fo r Zion
examination Table 2.	Cake Results	R
Recapitulation Feasibility Assessment of Fixation Tools		D 5
N R	R R	R
o Performance Test 1	2	r
3	4	

Fixation tools can help	
1 Performance	
5	5
Radiographer Poses N Cassettes	

Tools fixation can be used	
2 on	5
Babygram examination	

Tools fixation can	
3 Hold	4
Inspection object load	5

Quantity	14	1			
	2	5	4	3	2
Total	80				

Total Work Score = Total Score Questionnaire

Responden x Jumlah pertanyaan

80

= 4,4

18

Based on the calculation of the test result recap

The performance of the fixation tool was obtained as a total working value of 4.4. Therefore, it can be concluded that the babygram fixation tool has excellent performance, and the fixation tool does not cause artifacts.



DISCUSSION

The babygram fixation tool is a fixation tool used to make it easier for radiographers to fix positions patient at the *time of the babygram* examination. So there is no need to ask the patient's family for help to hold the patient's leg during the examination, so that the patient's family will not be exposed to radiation.

Design This babygram examination fixation tool is designed like the shape of a baby mattress, which functions as a base for babies to feel comfortable. The fixation tool that has been strung can be used on the babygram examination. The result of the babygram examination fixation tool is a tool made using foam, fabric and adhesive. Most of the raw materials are made of foam, the reason for using foam as a material for making this tool is because foam has a soft, elastic texture and can support objects.

The way this fixation tool works is very easy, namely by putting the tape under the mattress then positioning the patient in a supine position on the mattress that is comfortable to set the baby's position straight, hands up using upper extremity adhesive if needed, both legs are glued to the lower extremity adhesive and body step to support the baby's body so that it does not move easily.

1. **Function Test Results of Fixation Tools *babygram*** This babygram fixation device is carried out in two tests, namely a function test and a performance test. Where the test results are filled into Table checklist by six expert respondents, consisting of five radiographers Experienced and one radiologist specialist. Results of the assessment of the function test of the babygram fixation device

It includes five items, as follows:

- a. On adhesive items and seams can work well, as many as five respondents gave a score between 4 –5. Most respondents stated that this fixation tool has an excellent function.
- b. On mattress items and object placement pads working well, five respondents gave an average score of 4.6 indicating that the fixation tool

Provide optimal comfort for infant patients.

- c. On the item Easy to move fixation, five respondents gave an average score of 4.4 indicating that the tool is easy to use and lightweight to move between examination positions.
- d. On the object support foam item that is comfortable to use, five respondents gave an average score of 4.4 which indicates that soft foam material is very effective in supporting the baby's body.
- e. In the item of fixation tools that did not cause artifacts, the average value given by respondents was 4.4 which indicates that the materials that make up the tool are radiolucent and do not interfere with the results of radiographic images.

Based on the respondents' calculation and the calculation of the total working value, the function test obtained a score of 4.4. So it can be concluded that the babygram fixation tool has a very good function and the fixation tool does not cause artifacts.

2. **Results of the Performance Test of the Babygram Fixation Device** The results of the assessment of the performance test of the babygram fixation device include 3 items, as follows:

- a. On the item that fixation tools can help the radiographer's performance in positioning the tape, five respondents gave an average score of 4.4 which indicates that this fixation tool is effective in assisting radiographers in the process of determining the patient's position.
- b. On the item of fixation tools that can be used on the babygram examination, five respondents gave an average score of 4.6 indicating that the tool can be operated properly according to the needs of pediatric radiography examination.
- c. On the item of fixation tools that can be used in babygram examinations, five respondents gave an average score of 4.6 which indicates that the tool can be operated well according to the needs of pediatric radiography examinations.

Based on the calculation of the total working value, the performance test of the fixation tool obtained an average value of 4.4, which belongs to the category of excellent. This shows that the fixation device has high performance in supporting the radiography examination process, is easy to use, stable, and effectively improves the work efficiency of the radiographer.

The results of the function and performance test of the babygram fixation device show that this tool is very helpful in the process of radiography examination in infant patients. This finding is in line with the theory from Long, Rollins, and Smith (2015) which states that the fixation device in radiology functions an important function to reduce patient



movement, increasing comfort, and facilitate the positioning process by radiographers so that they can produce optimal radiography.

The theory from Lampignano & Kendrick (2020), also explains that the use of aids such as *Pigg-O-Stat*, *Tam-em Board*, and *Sponges* can significantly stabilize pediatric patients during examinations. These devices are designed to minimize radiation exposure to others in the examination room, particularly families who usually help hold infant patients.

Unlike standard commercial tools such as *Pigg-O-Stat* which uses hard acrylic materials and a vertical clamping system, this designed fixation device uses foam and fabric straps, making it lighter, economical, and easy to clean, but less stable when the patient makes sudden movements. As for comparison

With the *Tam-em Board* which is modular and can be adjusted in height and tilt, this fixation tool still has a simpler shape and cannot be adjusted to different baby body sizes. However, in terms of patient comfort, the soft foam material provides its own advantages over hard materials such as acrylic.

This supports that the fixation device designed in this study is able to replace the role of the patient's family, thus not only improving patient safety but also protecting the family from secondary radiation exposure.

The advantages of this fixation device are able to help the radiographer's performance in conducting babygram radiographic examinations, which is shown by a function test score of 4.4 and a performance test of 4.4. In terms of ergonomics, the use of soft foam and body straps such as those used in this tool is also in accordance with the principle of pediatric immobilization which prioritizes comfort and safety without causing excessive pressure on the baby's body (Iskandar et al., 2020). The soft foam texture and design that resembles a baby mattress are considered effective in keeping the baby's position stable and comfortable during the examination of the ALARA (*As Low As Reasonably Achievable*) principle in radiology which emphasizes the importance of reducing radiation dose to a minimum in patients and people around them also further strengthens the urgency of using fixation devices.

By not involving the family in holding the patient, this principle can be applied more effectively. This fixation device is able to reduce the patient's movement, as well as being able to replace the position of the patient's family in holding the patient during the examination and the fixation device does not cause artifacts. This is shown by the results of the function test which received a score of 4 (Daryati et al., 2016).

However, the use of foam as the main material also has limitations. Foam can experience a decrease in elasticity after repeated use, which can affect the comfort and stability of the patient's position. In addition, foam tends to absorb liquids and is difficult to disinfect optimally, so hygiene aspects need to be given more attention in long-term clinical use. In terms of mechanical structure, the use of fabric straps also has the potential to experience a decrease in adhesion after intensive use. Therefore, further development needs to consider the use of water-repellent and easy-to-sterilize synthetic materials, as well as the addition of stronger locking systems to make the tool safer when used in patients who are actively moving.

CONCLUSION

Based on the results of the function test and performance test of the babygram fixation device involving six expert respondents—consisting of an experienced radiographer and a radiology specialist—an average score of 4.4 was obtained in both aspects of the assessment. This value shows that the fixation device works very well, is able to support the examination object stably, provides comfort for the infant patient, and does not cause artifacts in the radiographic image. This tool has also been proven to assist radiographers in positioning the patient and the tape appropriately, thereby increasing the efficiency of the examination. In addition, the use of the babygram fixation device supports the application of the ALARA principle because it reduces the involvement of the patient's family in holding the baby during the examination, so that the risk of radiation exposure to other parties can be minimized.

Although the results obtained are excellent, the development of the tool is still needed to optimize its function, safety, and reliability. Improvements in the design and selection of materials that are more stable, resistant to repeated use, and easy to sterilize according to radiology room standards need to be considered. Going forward,

The development of a more robust and flexible locking system and a design that can accommodate different sizes of babies are also opportunities for improvement. Further research involving more experts in various healthcare facilities is expected to strengthen the validation of the feasibility and safety of this babygram fixation device.

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