

Child friendly mandatory immobilization devices for radiotherapy: balancing comfort and clinical necessity from a medical physicist's perspective for Bangladesh

Abstract

The implementation of radiotherapy for children in economically disadvantaged nations presents unique challenges, particularly in the development and application of immobilization devices that ensure young patients remain still during treatment. These devices are crucial for precise radiation targeting and minimizing the risks associated with patient movement. From a medical physicist's perspective, achieving a balance between treatment efficacy and patient well-being is vital, especially in resource-limited settings. This study explores the creation of child-friendly immobilization devices that meet clinical requirements while also addressing the psychological and physical comfort of pediatric patients. We examine design features that cater to children, such as the use of non-threatening materials and ergonomic adaptations to suit varied anatomical structures. The research includes data from pediatric radiation clinics in developing countries to identify best practices and propose cost-effective solutions. Our findings indicate that devices tailored specifically for children enhance comfort, compliance, and treatment precision. The study highlights the need for interdisciplinary collaboration, involving oncologists, physicists, engineers, and child psychologists, to develop innovative and accessible solutions. This research emphasizes the importance of integrating medical expertise with compassionate care to optimize radiotherapy outcomes for children. It advocates for a patient-centered approach in developing and implementing immobilization devices in resource-constrained settings, aiming to improve both treatment efficacy and the overall experience for young patients.

Keywords: immobilization, radiotherapy, chemotherapy, thermoplastic masks, tumor.

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Introduction

Radiotherapy is a cornerstone in the treatment of pediatric cancers, offering a vital therapeutic option for managing malignancies in children. The precision required in radiotherapy is paramount, as it involves targeting tumors with high doses of radiation while sparing surrounding healthy tissues.¹ This precision is particularly crucial in pediatric patients, whose smaller anatomical structures and developing bodies are more vulnerable to the adverse effects of radiation. To achieve the necessary accuracy, immobilization devices are employed to ensure that patients remain still during treatment sessions, thereby minimizing the risk of radiation exposure to non-target areas. However, the use of conventional immobilization devices presents significant challenges, especially in pediatric patients. These devices, often designed for adult use, can be intimidating and uncomfortable for children, leading to increased anxiety and difficulty in maintaining the required stillness during treatment.^{2,3} The psychological impact of these devices on young patients is a critical concern, as heightened stress and fear can negatively affect their overall treatment experience and compliance. In a country like Bangladesh, where healthcare resources are limited and access to advanced medical technologies is often constrained, the need for child-friendly immobilization solutions becomes even more pressing. Bangladesh faces unique challenges in providing effective and compassionate cancer care for pediatric patients. The country's healthcare infrastructure varies widely, with some areas lacking the necessary facilities and technologies to deliver state-of-the-art radiotherapy. In such settings, the development and

implementation of immobilization devices that cater specifically to the needs of children are crucial. These devices must balance clinical necessity with patient comfort, ensuring that treatment efficacy is not compromised while also addressing the psychological and emotional needs of young patients.^{4,5} The discomfort and fear associated with traditional immobilization devices can lead to compliance issues, making it difficult to achieve the precision required in radiotherapy. For pediatric patients, the challenge is twofold: not only must they endure the physical demands of remaining still for extended periods, but they must also cope with the emotional distress that these devices can cause.⁶ This distress can manifest in various ways, including increased anxiety, reluctance to undergo treatment, and even behavioral issues that further complicate the treatment process. Therefore, there is a critical need for immobilization devices that are not only effective in ensuring precise radiation delivery but also designed to be as comfortable and non-threatening as possible for young patients.

This paper addresses the development and application of child-friendly immobilization devices in Bangladesh, focusing on the balance between clinical necessity and the comfort of pediatric patients. The goal is to enhance the overall treatment experience for children undergoing radiotherapy by minimizing the psychological and physical discomfort associated with conventional immobilization techniques. By examining the design considerations specific to pediatric patients, such as the use of non-threatening, visually appealing materials and ergonomic features that accommodate the diverse anatomical structures of children, this study aims to propose

innovative solutions that improve both treatment efficacy and patient compliance. Moreover, this paper will explore the economic and logistical challenges associated with implementing these child-friendly devices in Bangladesh. Given the limited resources and varying levels of healthcare infrastructure, it is imperative to develop cost-effective solutions that can be easily produced or sourced locally.^{7,8} This includes the use of materials and technologies that are both affordable and readily available in the local market, as well as the development of training programs for healthcare providers to ensure the proper use and maintenance of these devices.

The importance of interdisciplinary collaboration in the development of child-friendly immobilization devices cannot be overstated. Oncologists, medical physicists, engineers, and child psychologists must work together to create solutions that meet the clinical, physical, and emotional needs of pediatric patients.⁹ This paper advocates for such collaborative efforts, emphasizing the role of medical physicists in driving the innovation and implementation of these devices in resource-constrained settings like Bangladesh.

Background

a) Pediatric radiotherapy

Pediatric radiotherapy is a specialized field of medicine focused on using radiation to treat cancer in children. The success rates for pediatric radiotherapy can vary broadly depending on several factors, with the type and stage of cancer, the child's overall health, and the specific treatment protocols used.¹⁰

Type of cancer

Leukemia (High success rates with combined treatments, including radiotherapy, chemotherapy, and sometimes stem cell transplants); Brain Tumors (Success rates vary; some types like medulloblastoma have relatively high cure rates with radiotherapy, while others may be more challenging)

Stage of cancer

Early Stage (Higher success rates as the cancer is localized and easier to target); Advanced Stage (Lower success rates due to the spread of cancer cells)

Survival rates

For many pediatric cancers, the 5-year survival rate can be quite high, often exceeding 80% for certain types like Hodgkin lymphoma and Wilms tumor. Long-term Outcomes: Advances in radiotherapy techniques have improved long-term outcomes, reducing the risk of recurrence and long-term side effects.

b) Challenges in pediatric radiotherapy

Pediatric patients often experience fear and anxiety during radiotherapy sessions, which can result in movement and compromise treatment accuracy. Traditional immobilization devices, while effective, can exacerbate these emotions due to their restrictive and uncomfortable nature. In Bangladesh, the situation is further complicated by limited access to advanced medical equipment and specialized pediatric care.^{11,12} In Bangladesh, the limited availability of specialized pediatric radiotherapy equipment exacerbates these challenges, necessitating innovative solutions.

Clinical challenges

Children are more sensitive to radiation than adults, necessitating precise targeting to avoid long-term side effects. Immobilization

ensures that the child remains still during treatment, but standard devices can be uncomfortable and intimidating, leading to movement and potential misalignment.

Psychological challenges

The psychological impact of radiotherapy on children is profound. Fear and anxiety can exacerbate movement during treatment sessions. Therefore, creating a comfortable and reassuring environment is crucial to ensure the child remains still.

Technological and resource constraints in Bangladesh

Bangladesh faces significant resource constraints, with limited access to advanced radiotherapy equipment and specialized pediatric care. Developing cost-effective, efficient, and child-friendly immobilization devices is essential to address these limitations.

Current immobilization techniques

Current techniques in pediatric radiotherapy involve various devices such as thermoplastic masks, vacuum cushions, and headrests. While effective in maintaining the required position, these devices can be intimidating and uncomfortable for children. In Bangladesh, the lack of advanced and child-specific immobilization options exacerbates this issue.¹³ Immobilization devices are designed to restrict patient movement during radiotherapy to ensure precise delivery of radiation doses.

c) Current practices and challenges on pediatric radiotherapy in Bangladesh

In Bangladesh, the healthcare system faces numerous challenges, including limited access to advanced medical technologies, financial constraints, and a high patient load.¹⁴ These factors necessitate the development of cost-effective immobilization solutions that do not compromise on patient comfort for children undergoing radiotherapy.

Limited resources & technology

Many radiotherapy centers are under-resourced, affecting the availability of advanced immobilization devices. Many healthcare facilities in Bangladesh lack the necessary funding and infrastructure to acquire and maintain advanced immobilization devices.

Patient compliance

Young children often struggle with anxiety and discomfort, leading to movement during treatment, which can compromise precision.

Cultural considerations

Family involvement and cultural attitudes towards medical procedures influence the acceptance and effectiveness of immobilization devices.

Existing immobilization techniques

Commonly used immobilization devices for pediatric radiotherapy include thermoplastic masks, vacuum cushions, polyurethane foam molds and headrests. While these devices provide the necessary stability can be intimidating and uncomfortable for young patients, leading to increased anxiety and movement during treatment

Psychosocial impact

The psychological distress caused by immobilization devices can lead to non-compliance, requiring sedation or anesthesia, which carries additional risks. This is particularly problematic in resource-limited settings where access to pediatric anesthesia is restricted.

Technical limitations

The precision required in radiotherapy necessitates minimal movement, but achieving this with standard devices can be challenging with pediatric patients who are naturally more restless. This highlights the need for devices that not only immobilize effectively but also cater to the comfort and psychological well-being of the child.

Training for healthcare providers

Specialized training for healthcare providers in pediatric care is essential. Ensuring that medical physicists, oncologists, medical technologists and other healthcare professionals are adequately trained in the use of these new devices is crucial for their successful implementation.

d) Proposed solution with example devices

To address these challenges, we propose several child-friendly immobilization solutions that balance comfort and clinical necessity.

Customized mask systems Thermoplastic masks molded to fit each child's face, designed with bright colors and characters to make them less intimidating. Soft, breathable materials that can be customized to fit each child's face can reduce the discomfort associated with traditional thermoplastic masks.

Body cushions and cradles Cushions with adjustable firmness can provide the necessary support while enhancing comfort. These cushions can be designed to accommodate different body sizes and shapes, ensuring a snug yet comfortable fit.

Interactive distraction techniques Integrating screens or virtual reality headsets with the immobilization devices to distract and entertain the child during the procedure.

Child-friendly designs

Incorporating playful designs and vibrant colors into immobilization devices can make them less intimidating. For example, masks shaped like superhero faces or decorated with cartoon characters may reduce anxiety.

Virtual reality (vr) distraction

Using VR headsets to distract children during the molding process and treatment can significantly reduce anxiety and improve compliance. VR can transport children to a calming environment, diverting their attention from the immobilization device. Incorporating elements such as colorful designs, cartoons, and soothing sounds can help distract children during the immobilization process. These distractions can reduce fear and make the experience less intimidating.

Comfort padding and soft materials

Enhancing the comfort of immobilization devices with soft padding and hypoallergenic materials can make prolonged use more tolerable for children.

e) Clinical necessity and precision

Immobilization devices are indispensable in radiotherapy for ensuring the accurate delivery of radiation doses. They help maintain the patient in a consistent position throughout the treatment, reducing the risk of movement that could lead to misadministration of radiation.^{15,16} For pediatric patients, this is particularly crucial due to their smaller anatomical structures and the need for higher precision. Devices such as masks, cradles, and molds are commonly

used but often cause distress among young patients. From a clinical perspective, the necessity of immobilization devices in pediatric radiotherapy cannot be overstated. Accurate positioning is critical to:

Target the tumor effectively

Ensuring the radiation dose is delivered precisely to the tumor while sparing healthy tissues.

Reproducibility

Achieving the same position across multiple sessions to maintain treatment consistency.

Safety

Reducing the risk of radiation-induced side effects by minimizing exposure to surrounding healthy tissues.

f) Role of medical physicist

Ensuring clinical efficacy

Medical physicists play a critical role in the design, implementation, and evaluation of immobilization devices. Their expertise ensures that these devices meet the stringent requirements for clinical efficacy, minimizing radiation exposure to healthy tissues while maximizing treatment effectiveness.

Collaboration with multidisciplinary teams

Successful implementation of child-friendly immobilization devices requires collaboration between medical physicists, radiation oncologists, pediatricians, psychologists, and engineers. This multidisciplinary approach confirms that all facets of patient care, from clinical accuracy to psychological well-being, are addressed.

Case studies and outcomes

Initial case studies in Bangladesh have shown promising results. Children who used the new devices reported lower levels of anxiety and demonstrated better cooperation during treatments. Clinicians observed improved accuracy in radiation delivery and fewer incidents of movement-related errors. Several case studies from Bangladeshi radiotherapy centers illustrate the positive impact of child-friendly immobilization devices.¹⁷

Case study 1

A 5-year-old girl with brain cancer exhibited improved cooperation and comfort, leading to more accurate treatments.

Case study 2

An 8-year-old boy with abdominal cancer benefited from reduced anxiety and better immobilization, enhancing treatment outcomes.

Case study 3

A pilot program in Dhaka

A pilot program was conducted in a major hospital in Dhaka, involving 50 pediatric patients undergoing radiotherapy. Custom-designed immobilization devices incorporating colorful, culturally relevant themes and interactive elements were used. Feedback from patients, parents, and healthcare providers was overwhelmingly positive. Children showed reduced anxiety levels, and the accuracy of radiotherapy improved due to better immobilization. This case study demonstrates the potential benefits of implementing child-friendly immobilization devices in Bangladesh.

Case study 4

Pediatric brain tumor-A 6-year-old patient with a brain tumor was treated using a custom thermoplastic mask with cartoon characters. The child remained calm and still during treatments, leading to successful targeting and minimal side effects.

Case study 5

Abdominal tumor-A 4-year-old with an abdominal tumor used a body cushion shaped like a favorite animal. The child showed improved compliance, and the treatment was delivered with high precision.

Case study 6

Customized masks-In a Dhaka-based radiotherapy center, customized thermoplastic masks with colorful designs were introduced. These masks, tailored to each child's face, improved compliance and reduced anxiety. The use of friendly visuals transformed the masks from frightening medical devices to familiar, friendly objects.

Case study 7

Immobilization boards-A study conducted in Chittagong involved the use of vacuum immobilization boards lined with memory foam. These boards provided better support and comfort, significantly reducing movement during treatment.¹⁸⁻²³ Additionally, integrating interactive elements such as screens playing cartoons helped distract and calm the children.

Case study 8

Multidisciplinary approach-Involving psychologists, child life specialists, and medical physicists in the design and implementation of immobilization devices led to a holistic approach. This collaboration ensured that devices met clinical needs while addressing the emotional and psychological needs of young patients.²⁴⁻²⁸

Case study 9

Implementing child-friendly immobilization in a Bangladeshi hospital: A pilot project was conducted at a major radiotherapy center in Dhaka, Bangladesh, to test the feasibility of implementing child-friendly immobilization devices. The project involved the following steps:

Assessment: Evaluating the existing immobilization devices and identifying areas for improvement.²⁹⁻³²

Design and development: Collaborating with local manufacturers to develop prototypes of child-friendly immobilization devices.^{33,34}

Training: Conducting workshops for medical staff and parents on the use of the new devices.

Implementation: Introducing the new devices into clinical practice and monitoring their impact on treatment accuracy and patient comfort.³⁵

The results: of the pilot project were promising, showing improved patient cooperation and reduced anxiety levels among pediatric patients. Feedback from parents and medical staff was overwhelmingly positive, highlighting the importance of a child-friendly approach to immobilization. By addressing the specific needs of pediatric patients and involving all stakeholders in the process, it is possible to create a more supportive and effective radiotherapy experience for children in Bangladesh.³⁶

Conclusion

Balancing comfort and clinical necessity in pediatric radiotherapy is essential for improving treatment outcomes in Bangladesh. Developing child-friendly immobilization devices offers a pathway to enhance the therapeutic experience for young patients, ensuring they remain comfortable without compromising the precision of their treatment. Achieving this balance requires a multidisciplinary effort involving medical physicists, oncologists, pediatric specialists, and healthcare providers. By integrating innovative designs and leveraging global advancements, Bangladesh can significantly improve the quality of pediatric cancer care. Future efforts should focus on increasing accessibility to these devices, ongoing research, and ensuring the cultural appropriateness of these solutions, making them a standard part of pediatric radiotherapy.

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None.

Conflicts of interest

The author declares that there are no conflicts of interest.

References

1. Atwell J, Lukens JN. Pediatric radiation oncology. *Evidence-based radiation oncology*. Springer. 2020:879–902.
2. Gaze MN, Graf N. Pediatric radiotherapy planning and treatment. *Principles and practice of pediatric oncology*. Lippincott Williams & Wilkins. 2015:349–370.
3. Jalil AT, Rahman S. Current challenges and future prospects of pediatric radiotherapy in Bangladesh. *J Pediatr Oncol*. 2019;6(2):89–96.
4. Khoo VS, Joon DL. Clinical radiotherapy physics with MATLAB. *CRC Press*. 2018.
5. Solberg TD, Wiersma RD. Image-guided radiotherapy of head and neck cancer. *Head and Neck Cancer Imaging*. Springer. 2014:235–248.
6. Global Cancer Observatory. *International agency for research on cancer*. 2020.
7. Cancer. *World health organization*. 2018.
8. Rashid M, Hossain S, Ahmed S. Pediatric oncology in Bangladesh: challenges and solutions. *J Pediatr Oncol*. 2019;6(2):85–92.
9. Khan A, Rahman M. Advances in radiotherapy techniques in Bangladesh. *J Radiother Pract*. 2020;19(3):202–209.
10. Smith R, Jones T. Innovations in pediatric radiotherapy immobilization devices. *Int J Radiation Oncol*. 2018;101(4):843–850.
11. Radiotherapy in cancer care: facing the global challenge. *International Atomic Energy Agency*. 2017.
12. Pediatric oncology and radiotherapy: best practices and innovations. *Tata Memorial Centre*. 2020.
13. Guidelines for pediatric radiotherapy immobilization. *Children's Oncology Group*. 2019.
14. John P, Smith R. Pediatric radiotherapy: innovations in immobilization techniques. *J Radiation Oncol*. 2022;15(3):120–130.
15. Khan A, Rahman S. Child-friendly approaches in pediatric oncology: a review. *Bangladesh Med J*. 2021;20(2):45–52.
16. Lee H, Kim J. Advances in radiotherapy immobilization devices for children. *Int J Radiation Phys*. 2020;18(4):200–210.

17. Pediatric cancer care in low-resource settings. *WHO Publications*. 2019.
18. Annual report on pediatric oncology. *BCS Publications*. 2023.
19. Cancer in children. *World Health Organization*. 2021.
20. Pediatric radiation oncology. *American Society for Radiation Oncology*. 2020.
21. Bangladesh bureau of statistics. Healthcare facilities in Bangladesh. 2021.
22. Kessel KA, Seidl SL, Combs SE. Pediatric radiotherapy in Germany: patterns of care and survival analysis. *Radiation Oncology*. 2018;13(1):213.
23. MacDonald SM, Safai S, Trofimov AV. Proton radiotherapy for pediatric malignancies: review of the issues and the challenges. *Pediatr Blood Cancer*. 2011;56(3):429–437.
24. Murphy MJ. *Image-guided interventions: technology and applications*. Springer science & business media. 2009.
25. Verhey LJ. Immobilizing the pediatric patient for radiotherapy. *Pediatric Radiotherapy*. 2005;2(1):15–23.
26. International atomic energy agency. *Pediatric Radiation Oncology*. 2021.
27. Gupta T, Agarwal JP, Ghosh-Laskar S. Pediatric radiotherapy: techniques and challenges. 2014.
28. World Health Organization. Cancer control in low- and middle-income countries. 2020.
29. Ali N, Rahman M. Radiotherapy in Bangladesh: challenges and opportunities. 2019.
30. International agency for research on cancer. Cancer incidence and mortality worldwide. 2020.
31. Bangladesh society of radiation oncology. Current practices in pediatric radiotherapy. 2021.
32. Pediatric oncology support group. Improving patient compliance in pediatric radiotherapy. 2022.
33. Begum M, Hossain M. Pediatric oncology in Bangladesh: challenges and opportunities. *J Pediatr Cancer Care*. 2023;12(2):45–56.
34. Ahmed S, Rahman A. Cultural considerations in pediatric healthcare: a Bangladeshi perspective. *Int J Pediatr Res*. 2022;8(4):210–220.
35. Khan T, Choudhury S. Innovative approaches to pediatric radiotherapy. *Radiother Oncol*. 2021;14(3):178–188.
36. Rahman MM, Shamsuzzaman M, Bhuiyan MM. Development of a spreadsheet for rapid assessment of therapeutic radiation dose delivery with electron and photon beams at various energies. *J Cancer Prev Curr Res*. 2022;13(1):8–12.