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The 3D-Printing Technologies in Radiotherapy: Current Trends, Innovations and Perspectives

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INTRODUCTION

Cancer, a complex and multifaceted disease, continues to be a significant challenge to global health systems, affecting millions of lives worldwide.
According to GLOBOCAN 2022, about 20 million cases of cancer were registered, mainly lung, breast and colorectal cancer.
Over the years, significant achievements have been made in the study of the molecular biology of cancer, the diagnosis of the disease and the development of effective treatment strategies. Among these advances is the implementation of 3D printing technologies (3D-PT) in oncology, especially in radiotherapy, which have revolutionized cancer management, offering immense potential in the personalized treatment of patients with various types of cancer.

METHODS AND MATERIALS

A literature review was conducted using scientific articles from the databases Google Scholar, NCBI/PubMed, Frontiers, Nature, Science Direct, 3D Printing in Medicine for a period of 5 years.
A visit was made to the Department of Radiotherapy, Oncology Center of the Greater Poland Voivodeship, Poznan, Poland.

RESULTS

The review of publications from online databases highlights recent advances in radiotherapy using 3D-PT in the management of cancer patients, including quality assurance phantoms, customized brachytherapy applicators, boluses, compensators and immobilization devices.

RESULTS

The use of 3D-PT in the creation of phantoms and applicators has helped to accurately model anatomical regions, reducing radiation doses and protecting adjacent healthy tissues. The use of boluses and 3D-printed compensators allowed the reconstitution of areas and organs subjected to irradiation in the case of brachytherapy sessions of surface forms of cancer (cancer of the skin of the nose, ears and eyes).
3D-PT is also used in the creation of personalized immobilization devices, so that maximum comfort is ensured for patients during radiotherapy sessions.

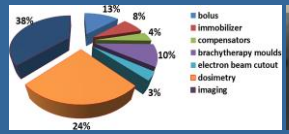

Fig.1. Current trend of 3D-PT applications in radiotherapy.

Fig.2. Dose measurement using EBT3 film and patient-specific chest phantom.

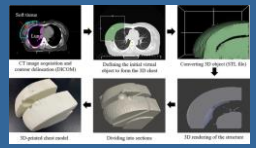

Fig.3. Schematics of creating 3D-printed chest phantom.

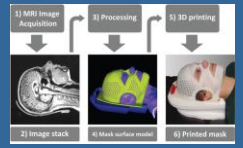

Fig.4. The process of manufacturing of a 3D-printed immobilization mask.

RESULTS

During the visit to the Radiotherapy Department of the Oncology Center of the Greater Poland Voivodeship, Poznan, Poland, the process of making and testing 3D-printed applicators for cervical, prostate and skin cancers of the fingers and nose was observed and analyzed using CT scans and Beben- DICOM to STL software.
FDM-3D printing technology allowed the creation of applicators from resistant materials, but also significantly reduced their manufacturing cost. The samples obtained were of high quality, ensuring targeted treatment with minimal risks to adjacent tissues and organs.

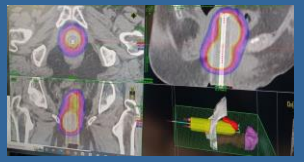

Fig.5. A customizable applicator for brachytherapy for cervical cancer, made by FDM-3D.

Fig.6 The use of the 3D-printed facial applicator in the treatment of basal cell carcinoma, nodular type, on the bridge of the nose.

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CONCLUSIONS

The 3D-printing technologies represent an innovative and practical way to promote and implement personalized medicine in the field of radiotherapy through the individualized management of cancer patients, providing a targeted and effective therapeutic response.