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Development of CT/MR Compatible and Adjustable Non-Invaziv Intravesical High Dose Rate Brachytherapy Applicator Prototype for Treatment of Bladder Cancer

Mesane Kanseri Tedavisinde Kullanılmak Üzere CT/MR Uyumlu ve Ayarlanabilir Non-İnvaziv İntravezikal Yüksek Doz Hızlı Brakiterapi Aplikatörü Prototipinin Geliştirilmesi

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Abstract: Bladder cancer is a major health problem affecting people all over the world, especially older people. Many of the patients prefer an organ-sparing approach because they cannot be operated for medical reasons or because they do not want to. External radiotherapy and brachytherapy treatments are part of the organ preservative treatment and the current brachytherapy applications are performed interstitially. This interventional procedure is performed under anesthesia in the operating room, hospital stay and cost is a significant problem and may increase according to the complications. The aim of this study is to develop CT/MR Compatible and Adjustable Non-Invaziv Intravesical High Dose Rate Brachytherapy Applicator for bladder cancer treatment in order to eliminate the need for anesthesia, shorten recovery time, reduce cost and provide a direct economic contribution.
Keywords: Non-Invaziv Intravesical High Dose Rate Brachytherapy Applicator Prototype, Bladder Cancer

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Özet: Mesane kanseri tüm dünyada özellikle de ileri yaştaki insanları etkileyen önemli bir sağlık sorunudur. Hastaların birçoğu medikal nedenlerden dolayı cerrahi olamadıkları için ya da istemedikleri için organ koruyucu yaklaşımı tercih etmektedirler. Eksternal radyoterapi ve brakiterapi tedavileri organ koruyucu tedavinin bir parçası olup mevcut brakiterapi uygulamaları intertisyel olarak yapılmaktadır. Bu intertisyel uygulamanın ameliyethane şartlarında ve anestezi altında yapılması, uygulama sonrası hastanede kalış süresi ve maliyet önemli bir sorun olup oluşabilecek komplikasyonlara göre artış gösterebilmektedir. Bu çalışma ile anestezi ihtiyacını ortadan kaldırmak, iyileşme süresini kısaltmak, maliyeti düşürmek ve doğrudan ekonomik katkı sağlamak adına mesane kanseri tedavisinde kullanılmak üzere CT/MR Uyumlu ve Ayarlanabilir Non-İnvaziv İntravezikal Yüksek Doz Hızlı (HDR) Brakiterapi Aplikatörünün geliştirilmesi amaçlanmıştır.
Anahtar Kelimeler: Non-İnvaziv İntravezikal Yüksek Doz Hızlı Brakiterapi Aplikatörü Prototipi, Mesane kanseri

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1. Introduction

Bladder cancer is an important health problem worldwide that affects older people, especially and organ-preserving approaches may be preferred because many patients cannot be operated due to medical comorbidities or they do not want surgery (1,2). External radiotherapy and brachytherapy treatments are part of organ-sparing treatments and nowadays actual brachytherapy applications are performed interstitially (3-7). Performing this interstitial approach in the operating room and under anesthesia, the duration and cost of hospitalization after the application is an important problem and these problems may increase according to the complications which may occur (8-10). In this study, we aimed to develop a CT / MR compatible and adjustable non-invasive intravesical high dose rate (HDR) brachytherapy applicator to be used in bladder cancer treatment in order to eliminate the need for anesthesia, shorten recovery time, reduce costs and provide a direct economic contribution.

2. Material and Method

To the production of the prototype in this project, silicon modeling was made by the tender company after 3D sketches, model drawings, and preparation of simulations (Figure 1). The produced applicator consists of a silicone balloon, 6 channels located on the wall of the balloon where the radioactive source will be loaded, a central catheter to be used to inflate the balloon, and a valve mechanism to prevent air escape from the balloon.

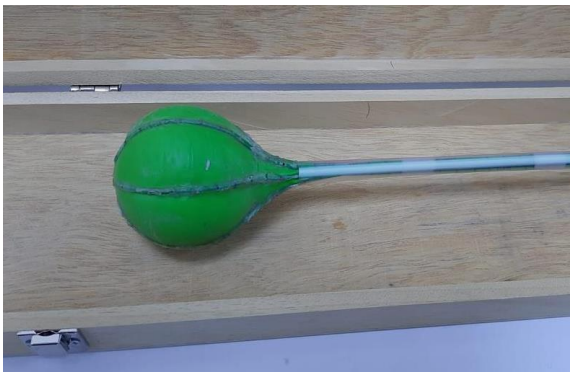

Figure 1. The inflatable appearance of the applicator

In order to make 3-dimensional brachytherapy dose planning using this prototype produced using silicone and plastic tubes, a sphere was used with a wall thickness of 0.8 cm from the wax which is accepted as a tissue-equivalent to imitate the bladder (Figure 2). This sphere was produced as 2 hemispheres by handwork using pure wax and then combined.

Figure 2. Wax sphere

After the prototype was placed in this sphere, the applicator was inflated with air to allow the channels on the wall of the balloon to touch the inner surface of the sphere. To make dose calculation, a planning tomography with a 1 mm cross-section was taken using computerized tomography (CT) device in this position (Figure 3).

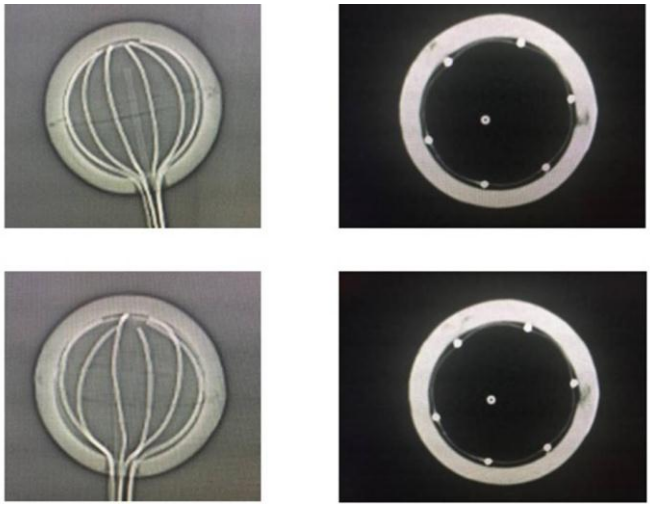

Figure 3. Scout and sectional images of computed tomography taken after placing the applicator into the wax sphere

Looking at the computed tomography images taken, it is seen that the balloon and channels of the applicator touch the inner surface of the sphere. The dose calculation phase was done using the Eclipse (Version: 15.6) treatment planning system after contouring the sphere as the bladder wall using these images obtained from CT (Figure 4).

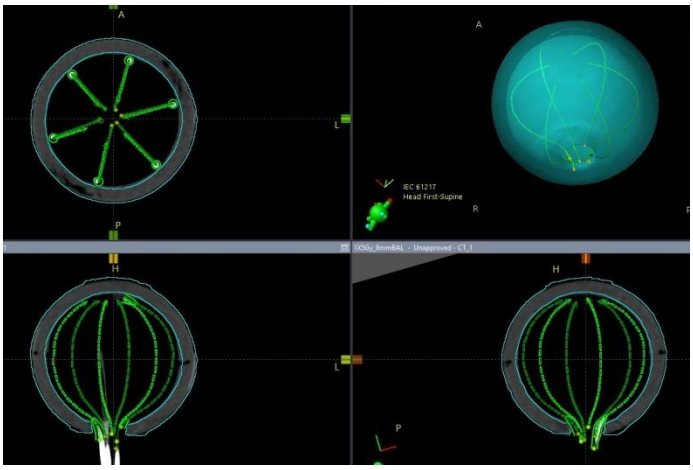

Figure 4. The contour of the sphere and the applicator in different axes and its 3-dimensional appearance

3. Results

In the planning, a calculation was made as used by the images of the sphere containing the applicator by accepting the entire wall of the sphere as the target volume and 95% of the target was ensured to receive 100% of the dose. For this purpose, Dwell position times were manually intervened. Dose-volume histograms (DVH) and dose staining images of all these plans are given in Figure 5. It is planned to give a dose of 5 Gy to the target in the dose planning and it has been shown that 98.6% of the target volume receives 100% of the dose.

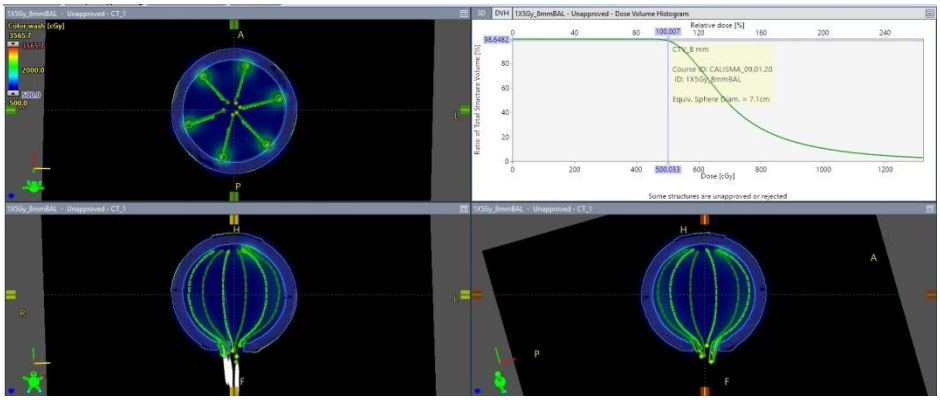

Figure 5. Dose color wash and dose-volume histogram images for 5 Gy

4. Discussion

As a result of the literature search, there is no study on this subject. Within the scope of the project, a patent application has been filed for our country and it is still in the evaluation process. With this project, we have tested the feasibility of an intracavitary brachytherapy applicator that can be applied non-invasively in the treatment of bladder cancer. Here, initially, the bladder has been assumed to be a sphere and it was aimed to wrap the entire wall of this sphere, which is 8 mm, with the desired dose. But, In accordance with personalized treatments, the design of the balloon applicator, number of channels, position and locations will be able to design according to the individual in the presence of disease that involves only a certain area of the bladder. In vitro dose measurements of this applicator that produced as a prototype should be made. Due to the cost of equipment required for these measurements and the limited budget of our project, these operations will be carried out in the next step.

5. Acknowledgment

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