蒙地卡羅方法模擬瓦利安直線加速器楔形濾器下射束特性研究

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摘要

研究目的：實體楔形濾器在傳統放射治療上運用相當普遍，透過楔形濾器，可以讓相切照野的劑量分布更均勻。一般而言，直線加速器的射束在經過楔形濾器之後，會產生一些特性上改變，而這些特性改變是無法在實際測量中測得，本研究希望透過蒙地卡羅模擬來得知此特性的變化。

材料與方法：以 BEAM 程式模擬瓦利安直線加速器（VARIAN Clinac 21EX）6 百萬電子伏特之輸出，本研究中機頭下方加入臨床使用之楔形濾器組件，並透過實際測量各角度濾器之尺寸，以感應耦合電漿質譜儀完成楔形濾器金屬材質鑑定，並於 BEAM 程式 pegs4 中建立幾何元件及作用截面，以符合實際機頭與楔形濾器環境。在 BEAMnrc 程式中，均勻照野（open field）及楔形濾器照野（wedge field）在 95 公分處的相空間粒子檔均被建立；透過 DOSXYZnrc 軟體建立與實際量測劑量所使用之自動化水箱一致的環境，並以該相空間粒子檔當作射源模擬不同照野大小、深度等條件下，百分深度劑量（percentage depth dose, PDD）與劑量剖面（dose profile），同時與以游離腔量測到的劑量做比對驗證。使用 BEAMDP 程式，分析出不同條件下相空間粒子檔的各項射束特性的變化。

結果與討論：對於 10x10 cm2 開放照野及含有 15、30、45、60 度楔形濾器的 10x10 cm2 照野已模擬完成，其劑量分布與水箱量測值有一致的結果。運用 BEAMDP 分析不同組件下所產生的相空間粒子檔，並與均勻照野比較，結果顯示，在 30 度楔形濾器照野因低能光子與濾器作用因素造成射束硬化，使輸出平均能量較均勻照野增加 20%。因為減少了電子汙染，形成增建區（build-up region）之劑量下降 3%。

結論：在本研究中，發現楔形濾器照野，粒子穿過介質後產生能量與能量通量射束硬化。蒙地卡羅程式是研究劑量變化的有效方法，本研究所建立的楔形濾器模組與程式輸入檔，可以運用在後續的研究上。

關鍵詞：蒙地卡羅、楔形濾器、直線加速器

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Beam Characteristics of Physical Wedges for a Varian Linear Accelerator：A Monte Carlo Study

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Abstract

Purpose：Physical wedges (PWs) are commonly used as beam modifying devices in clinical radiation therapy to optimize the target volume dose distribution. The main applications of PWs were used for clinical treatment. The aim of this study is to investigate the beam characteristics which are difficult to be evaluated by measurements.

Material and methods：The user code ′BEAM′ was used to simulate 6 MV photon beam generated by a Varian 21EX LINAC. In this study, the new PWs component modules (CMs) were established in LINAC head by BEAMnrc. The elemental compositions of PWs were determined by ICP-MS. The PWs and open fields phase-space data were also accumulated in BEAMnrc. Dose distributions in water phantom were performed by DOSXYZnrc. The percentage depth dose (PDD) and dose profile of simulations were verified with measurements, which were performed by automatic water tank and ionization chamber. Another utility code 'BEAMDP' was used to analyze these phase-space data for beam characterizations.

Results and Discussion：Monte Carlo simulations for PWs and open fields were validated first with the measurements for a 10x10cm2 field with all wedges. The results show good agreements between the simulated and measured dose distribution in PWs and open fields. The PDD curve for the open field is also included to demonstrate the effects of beam hardening due to the PWs. The BEAMDP calculation reveals that PWs can result in about 20% increase in mean photon energy due to the effect of beam hardening. In addition, about 3% dose reduction in the build-up region was found, which is due to the reduction of contaminated electrons by the 30 degree PW.

Conclusions：The particles passing through PWs will be hardened in energies and energy fluences. The Monte Carlo simulation is an accurate method to investigate dosimetric characteristics. The established component modules and the derived input data of the physical wedges can be used in further studies.

Keyword：Monte Carlo, Physical wedges, LINAC