中文摘要

放射線手術(SRS)運用於顱外腫瘤治療，可減少腫瘤週圍重要器官受放射線影響的體積。電腦刀(CyberKnife®)系統中的 Synchrony™ 呼吸同步追蹤系統(RTS)是運用腫瘤與植入於體內的定位標記物(fiducial markers)，在呼吸時位移之相對關係，建立出數學對應模式，來預估腫瘤的移動。RTS 可連續追踪腫瘤的位置、預期腫瘤之移動、並即時自動同步修正放射線投予之方位。我們使用一個內部已植入了定位標誌物及驗證片(Gafchromic film)的球型假體來驗證 RTS 在即時追踪胸部腫瘤移動之準確性。本實驗於呼吸靜態期、呼吸運動期及運用呼吸追踪系統補償後，分別作實驗研究。將球型假體放置於模擬呼吸週期用的移動假體上，放置於中心位置時為呼吸週期之中心點，置於上端時為吐氣終點，下端為吸氣終點。在未使用 RTS 時，電腦刀定位於呼吸週期的中心點，吐氣終點及吸氣終點的整體誤差分別為 0.76 ± 0.14mm，10.86 ± 0.29mm 及 11.16 ± 0.45mm。在使用 RTS 後，整體誤差分別為 0.33 ± 0.13mm，0.42 ± 0.66mm 及 0.30 ± 0.66mm。本研究驗證了運用 Synchrony™ RTS，可建立胸腔腫瘤於呼吸週期時位移，與植入的定位標誌物位置之非線性對應模式，並有效提供放射線手術治療時同步追踪定位腫瘤位置，以達到毫米下之整體定位準確度。

關鍵字: 電腦刀、呼吸同步追踪系統

INTRODUCTION

Since thoracic tumor usually locates beside the spine and the heart, stereotactic radiosurgery (SRS) has been used to minimize the volume of these surrounding critical structures irradiated. It is difficult to apply SRS to extracranial sites mainly due to respiration inducing significant movement of tumors in the thoracic and abdominal structures. Among the extracranial organs, thoracic tumor position changes during the respiratory cycle [1]. Reducing the discrepancies in tumor position between planning and treatment caused by setup errors and organ motion are crucial in designing the tightest possible safety margin without compromising the tumor coverage and normal lung tissue irradiated [2]. Image-guided radiosurgery offers the potential for precise radiation dose delivery to a moving tumor. To examine the motion of tumors during respiration, Ekberg et al. [3] used fluoroscopy to monitor the movement of clinical target volume (CTV). There is an average movement of 3.9 mm (range: 0–12 mm) in the superior-inferior (S/I) direction, 2.4 mm (range: 0–5 mm) in the left-right (L/R) direction, and 2.4 mm (range: 0–5 mm) in the anterior-posterior (A/P) direction. The respiratory movement of lung tumors in the lower lobe has been estimated to be as much as 9.1 mm (range 3.4–24.0) in the S/I direction and 10.1 mm (range 0–22) in the A/P direction [4]. Significant normal tissue sparing can be gained through the use of respiration monitoring and motion tracking technique.

Two approaches have been developed to manage organ motion in respiration cycle. The first approach is to reduce respiration tumor movement by maintaining a breath-hold, either actively or passively. Breath-hold method minimizes the effects of breathing motion by delivering radiation during the breath-hold period [5,6]. But breath-hold method is not applicable to most patients due to poor compliance. The second is the respiratory gating approach that allows the patient to breathe normally with radiation delivered in a pre-defined phase of the respiratory cycle or continuously delivered while tracking the tumor. The positions of the tumor are determined by monitoring the

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