Multi-Fold Radiation Therapy (MFRT)

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May 1, 2015
Purpose

• To develop a technique to create a treatment plan consisting of multiple sub-plans in order to achieve higher levels of conformity, and reduced dose to normal tissue, without increasing treatment delivery time or MUs
MFRT Method

• Rather than using a single plan throughout the entire treatment course, several sub-plans are created $P_1, P_2, P_3, P_4, P_5$

• Each sub-plan provides full dose coverage to the PTV and the dose to the critical structures is within toxicity tolerances
MFRT Method

• The sum of these multiple sub-plans forms one cycle or “fold” treatment that will be repeated until the total dose is reached

• The resulting plan sum of all sub-plans is superior in both tumor dose coverage and dose reduction to normal tissue
# Conventional Treatment

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## Multi-Fold Radiation Therapy

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1-Fold
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6-Fold
Why?
IMRT Segments

- Advantage of IMRT is segments
- Conventional Example:
  - If $P_1 = 200$ segments
  - Total = 200 segments over entire treatment
IMRT Segments

- MFRT Example:
  - $P_1 = 200$ segments
  - $P_2 = 200$ segments
  - $P_3 = 200$ segments
  - $P_4 = 200$ segments
  - $P_5 = 200$ segments
  - Total = 1000 segments over entire treatment!

<http://bjr.birjournals.org/content/vol76/issue910/images/large/BJR25984-1.jpeg>
How?
Example

- Head and Neck 6996 cGy in 33 fx
- 3-sub plans $P_1$, $P_2$, and $P_3$
- 11-Fold MFRT
Creating $P_1$

- Plan $P_1$ is created
  - $P_1$ is assigned the full dose of 6996 cGy
  - $P_1$ is optimized like normal
Creating $P_2$

- $P_1$ is copied, pasted, and named $P_2$
  - Each plan is assigned $\frac{1}{2}$ the total dose
    - $P_1 = 3498$ cGy
    - $P_2 = 3498$ cGy
Optimization of $P_2$

- $P_1$ is set as a base dose plan
- Optimizing criteria for each structure is made more stringent
- $P_2$ is optimized
Creating $P_3$

- $P_2$ is copied, pasted, and named $P_3$
  - The 3 plans are each assigned $\frac{1}{3}$ the total dose
    - $P_1 = 3498$ cGy
    - $P_2 = 3498$ cGy
    - $P_3 = 2332$ cGy
  - The plan sum $P_1 + P_2$ is created
Optimization of $P_3$

- $P_1 + P_2$ is set as a base dose plan
- Optimizing criteria for each structure is made more stringent
- $P_3$ is optimized
Final MFRT Plan Sum

- The plan sum $P_1 + P_2 + P_3$ is created

- Sub-plans $P_1$, $P_2$, and $P_3$ are repeated until the total dose is reached.

- 11-Fold MFRT

- It is superior in both tumor dose coverage and dose reduction to normal tissue.
The MFRT technique was applied to 6 previously treated radiation therapy cases:

- 3 prostate RapidArc cases
- 3 three head & neck RapidArc cases
- 5 Sub-plans were used for each case
- All MFRT sub-plans had the same gantry, collimator, couch angles, and field angles as the original treatment plan
- Avoidance structures, dose “help” structures, and rings contoured on the original plan were not used
Case 1: Prostate

- PTV: prostate and nodes
- Prescription: 25 fx, 180 cGy/ fx, 4500 cGy total
- 2 full Arcs
DVH: Original vs MFRT
DVH: Original vs MFRT
Case 2: H&N

- 3 PTVs
  - High Risk PTV
  - Medium Risk PTV
  - Low Risk PTV
- Prescription: 33 fx, 212 cGy/fx, 6696 cGy total to High risk PTV
- 4 full Arcs
DVH: Original vs MFRT

- Brainstem
- Trachea
- Spinal Canal
- Mandible
- PTV LR
- PTV IR
- PTV HR

Ratio of Total Structure Volume [%]
DVH: Original vs MFRT

Parotid, R
Parotid, L
Esophagus
PTV LR
PTV IR
PTV HR
Conclusion

• Improved dose distributions requires more segments or more beams
  • Requires a longer treatment time
  • Increase in leakage radiation (excess MUs)
Conclusion

• MFRT allows for many segmentations while maintaining a short treatment time and low radiation leakage

• Less radiation delivered to surrounding healthy tissue and organs

• More conformal treatment to the shape of the tumor

• This could be implemented as an automatic software feature in the TPS
Acknowledgments

• Xiaodong Wu, Ph.D., Biophysics Research Institute of America

• Weizhao Zhao, Ph.D., Department of Biomedical Engineering at the University of Miami

• Elizabeth Bossart, Ph.D., Kelin Wang, Ph.D., Sylvester Comprehensive Cancer Center at the University of Miami

• Bruce Phillips, South Florida Radiation Oncology
Thank U!


