SKIN DOSE DIFFERENCES BETWEEN IMRT/VMAT AND BETWEEN BOOST/INTEGRATED TREATMENT REGIMENS FOR TREATING HEAD AND NECK, PROSTATE AND BRAIN CANCERS

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Purpose of the Study

- Evaluate dose to skin between VMAT and IMRT treatment techniques for targets in the head and neck, pelvis and brain
- Determine if the treatment dose and fractionation regimen impacts the skin dose between traditional sequential boost and integrated boost regimens
Materials and Methods

• This was a retrospective study using Varian Eclipse Treatment Planning System
• anisotropic analytical algorithm (AAA) v11
Patients

- 19 Patients selected
  - 9 head and neck
    - Involved supraclavicular regions
  - 5 prostate
    - 3 with involved nodes
  - 5 brain
    - Various locations, large laterally located
- Each patient planned with VMAT and IMRT to clinically acceptable plans
  - Same target objective and organ constraints
  - No extra sparing to skin with either method
- Note orientation described: $180^\circ$ is gantry pointed towards floor (AP beam on supine oriented patient)
Head and Neck Plans

- 6MV
- VMAT → 2 Full Arcs
- IMRT → 7 beams ranging from 20° – 340° (more anterior)
- 6 traditional sequential boost:
  - 5040cGy in 25 fx → boost to 6930cGy in 33fx
- 3 integrated boost (1 replan w/ traditional boost):
  - Low target: 5400-5600cGy, Med Target: 6300cGy, high target: 7000cGy in 35fx
Prostate Plans

- Planned using 10MV photons
- VMAT → 2 full arcs
- IMRT → 7 fields spaced by 50° from 50°-350°
  - 1 plan w/o nodes used 5 field at 40°, 120°, 180°, 240° and 320°
- Primary Plans → 5040cGy in 28fx boost 7920cGy in 44fx
- 1 prostate bed → 7020cGy in 39fx
Brain Plans

- 6MV Photons
- VMAT $\rightarrow$ 2 partial arcs $\sim 180^\circ$-210$^\circ$ long
- IMRT plans $\rightarrow$ 5 fields various angles
  - Fields covered same angle range as arcs
  - 1 Plan had a noncoplanar beam
- Various prescriptions
  - 4500cGy in 25 fx $\rightarrow$ 6000 cGy in 30 fx
Quantify Skin Dose

• Skin 5mm deep from surface on axial slices-PTV contours present
• Mean skin dose noted
• Maximum dose noted (2cc contiguous volume)
  • Dose volume contours made to visualize hottest region
  • Noted as $D_{2\text{contig}}$ (Head and Neck and Brain)
  • 5cc contiguous volume -> $D_{5\text{contig}}$ (Prostate)
• Head and Neck Skin Split into three sections
  • Skin on jaw → all but posterior skin (very low doses)
  • Skin on neck → all but posterior skin (very low doses)
  • Skin on shoulder → only anterior portion of skin (low doses)
Results Head and Neck

• In general VMAT reduced skin doses
• Largest difference in shoulder
  • Mean decreased by 142cGy (5.6%)
  • $D_{2contig}$ decreased by 268.9cGy (5.4%)
• Neck:
  • Mean decreased 142cGy (3.9%)
  • $D_{2contig}$ decreased by 98.4cGy (1.9%)
• Jaw:
  • Mean decreased by 123cGy (5.1%)
  • $D_{2contig}$ decreased by 256cGy (5.1%)
Integrated vs Traditional boost

- Traditional Boost plans had a decreased skin dose in shoulder
  - Specifically $D_{2\text{contig}}$ in shoulder region

- Shoulder:
  - Mean dose:
    - IMRT: 44cGy (1.6%)
    - VMAT: 43cGy (1.7%)
  - $D_{2\text{contig}}$:
    - IMRT: 1805cGy (28.9%)
    - VMAT: 1367cGy (24.0%)
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* primary plus boost plan
† integrated boost plan
‡ traditional boost plan
## Head and Neck $D_{2\text{contig}}$ in cGy

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† integrated boost plan
‡ traditional boost plan
Integrated vs Traditional

- Integrated regimens $\rightarrow$ higher skin dose to shoulders
- Ideas why:
  - Integrated boost $\rightarrow$ higher prescription to target
    - $5400\text{cGy vs } 5040\text{cGy}$
  - Integrated boost $\rightarrow$ larger field entire treatment course
    - More modulation, more scatter, more leakage
Results Prostate and Brain

- VMAT in general reduced skin dose
- Large difference in Contiguous Hotspot
  - Prostate $D_{5\text{contig}}$ reduction: 880cGy (36%)
  - Brain $D_{2\text{contig}}$ reduction: 235cGy (6.5%)
- Mean dose reduction not as large
  - Prostate reduction: 51cGy (5.5%)
  - Brain Reduction: 86cGy (4.4%)
Conclusions

• VMAT in general will reduce skin dose while providing similar target coverage and other OAR sparing
  • Particularly contiguous hotspot regions
    • Increase # of entry angles $\rightarrow$ decrease hot spots
      • Not as much of advantage for partial arcs
    • Distance from target
      • Streaking effect for deep targets (Prostate plans, shoulders in Head & Neck plans)

• Using a traditional sequential boost regimen reduces contiguous hotspot in the shoulder region in head and neck patients
References

Special Thanks

• Dr. Jostin Crass DMP
• Wyndee Kirby MS
• Guozhen Luo MS
• Dr. Manuel Morales PhD
• Patricia Thompson CMD
• Drew Dellamonica MS
THANK YOU!
QUESTIONS?
# Prostate Patient Skin Dose Differences in cGy

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Skin mean doses, $D_{5\text{contig}}$ and the difference between IMRT and VMAT for pelvis located cases in cGy. *includes boost for the corresponding patient.
## Brain Plan Skin Dose Differences in cGy

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Skin mean doses, D$_{2\text{contig}}$ and the difference between IMRT and RapidArc for Brain cases in cGy. *includes boost for the corresponding patient. †IMRT plan using a non-coplanar beam.
Things to Consider

- Skin sparing between primary and primary + boost were similar → reported difference between primary plans
- One patient in each region planned w/ primary and boost to show this
- Regions of skin inside PTV → not included
  - Directly adjacent included (increase mean and max)
Where to go from here

• More plans → better statistics

• Confirm calculated skin doses →
  • AAA ok for build up region? → AAA does well up to 2mm^{11,12}
  • Measurements
    • TLD, OSLD, Film
    • Monte Carlo Comparison
Capabilities of IMRT

- Create conformal dose distributions and avoid OARs\textsuperscript{1,2}
- Complex tumor shapes
- Many Organs at risk (OARs) surrounding volumes
- Allow for dose escalation
- VMAT shown to produce similar dose distributions\textsuperscript{3,4,5,6}

Nicolini \textit{et al.} \textit{Radiation Oncology} 2009 4:27
Inverse Planning

- Divides beam into beamlets
  - Beamlets weighted based on predetermined organ tolerance criteria
- Fluence pattern

IMRT vs VMAT

**IMRT**
- Fixed gantry beams
  - Streaking creating unwanted high dose regions in normal tissue can occur

**VMAT**
- uses dynamic MLCs, dynamic gantry rotation and varying dose rate
  - More entry angles \( \rightarrow \) spreads out dose more
  - Larger low dose regions, lower higher dose regions\(^8\)
Skin Dose

- Streaking in IMRT can create hotspots in skin
  - Skin reactions occur in head and neck patients with IMRT\textsuperscript{9}
  - Hot spots in skin can occur in deep targets (pelvis)
- Can VMAT remove hotspots?
Plan Comparison

Patient 16

A: Axial dose plane VMAT
B: Coronal dose plane VMAT
C: Sagittal dose plane VMAT
D: Axial dose plane IMRT
E: Coronal dose plane IMRT
F: Sagittal dose plane for VMAT
DVH Comparison

Patient 16: Cyan: Skin Neck, Red Skin Jaw, Yellow, Skin Shoulder: Triangle = IMRT
Squares = VMAT

Patient 18: Cyan: Skin Neck, Red Skin Jaw, Yellow, Skin Shoulder
Triangle = VMAT
Squares = IMRT
Plan Comparison

Patient 5 A: Axial dose plane IMRT B: Coronal dose plane IMRT C: Sagittal dose plane IMRT D: Axial dose plane VMAT E: Coronal dose plane VMAT F: Sagittal dose plane VMAT plan
Patient 5: DVH plot: PTV (gold), CTV (orange), ROI skin dose (yellow) and $D_{5\text{contig}}$ contour (pink). VMAT - squares, IMRT - triangles
Patient 9: **A:** Axial dose plane VMAT **B:** Coronal dose plane VMAT **C:** Sagittal dose plane VMAT **D:** Axial dose plane IMRT **E:** Coronal dose plane IMRT **F:** Sagittal dose plane IMRT
Patient 9: DVH plot: PTV (magenta), CTV (violet), ROI skin dose (yellow) and $D_{2\text{contig}}$ contour (pink). VMAT- triangles, IMRT – squares.
Quantify Skin Dose

• Skin 5mm from surface circumferentially in axial slices - PTV contours present

• Mean skin dose

• Max dose in 5cc contiguous region
  • Noted as $d_{5\text{contig}}$
Quantify Skin Dose

• 5mm deep from surface axial slices → PTV present
  • 5°-10° past each partial arc
  • One noncoplanar static field → skin in beams eye view

• Mean Skin Dose

• $D_{2\text{contig}}$
Skin Dose Dependencies

- Increase # of entry angles $\rightarrow$ decrease hot spots
  - Not as much of advantage for partial arcs
    - Brain $\rightarrow$ noncoplanar beams

- Distance from target
  - Skin dose in general lower further from target
    - Streaking effect for deep targets (Prostate plans, shoulders in Head & Neck plans)