TomoTherapy® Radixact® and CyberKnife® M6™ Systems: The Miami Cancer Institute Clinical Experience

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Objectives

1. Describe the Radixact® and CyberKnife® M6™ System experience at MCI since January 16, 2017

2. Describe how patients are prioritized for Radixact® and CyberKnife® M6™ Systems at MCI

3. Review MCI cases that illustrate the clinical utility of Radixact® and CyberKnife® M6™ Systems
Baptist Health South Florida

• Largest non-profit healthcare organization in South Florida with 7 hospitals and nearly 50 outpatient and urgent care facilities

• Second largest employer in the state of Florida

• More than 16,000 employees and 2,400 affiliated physicians in virtually all specialties
Grand Opening: January 16, 2017
Miami Cancer Institute Statistics

• 440,000 square feet, $430 million
• 7 state-of-the-art photon therapy machines
• 3 gantry pencil beam scanning proton therapy center
• State of the art imaging
  • 2 dual source CT’s; Wide Bore CT; 2 PET/CT; 2 MRI’s; 4 Ultrasounds; 2 Mammography; 2 Stereotactic Tables; SPECT/CT; X-Ray
• >5,000 new pieces of medical equipment
• $25 million on IT related systems and hardware
  • New electronic medical records system
  • New patient treatment planning systems
• 113 Patient friendly exam rooms; 60 infusion rooms / 8 infusion beds
Miami Cancer Institute = Comprehensive

Best evidence-based treatment for any given disease

Radixact®
CyberKnife® M6™
Varian® TrueBeam™
GammaKnife® Icon™
ViewRay® MRIdian™
IBA Proteus® PLUS
Brachytherapy
Total Treatments Delivered
(Mar'17 - Mar'18)
Treatments Delivered per Vault (Mar'17 - Mar'18)
Radixact® In the Clinic
A Single Platform to Revolutionize Your Practice

Patients reeling from diagnoses need precise and effective treatment to get their lives back. Treatment teams need next-level precision and efficacy to improve patient outcomes. Clinical practices need the ability to treat a broad range of indications with superior outcomes. Reputation and patient lives are at stake. The Radixact™ Treatment Delivery System enables all of this with a fully integrated platform for intelligent treatment planning, data management and treatment delivery. Using a refined x-ray beamline and next generation CTrue™ imaging technology, the system delivers scalable, highly precise treatment for patients with a variety of individual clinical needs.
Radixact® = Treatment Versatility

- Our most complicated IMRT cases
- Curative and palliative 3DCRT patients
- Extended field
Radixact® = High Treatment Planning Efficiency

• Faster plan optimization

• Faster plan review
  • Up to 4 plans on each planning computer
  • Compare 2 plans calculated on the same planning image

• PreciseART™ Adaptive Radiation Therapy option “automated” module

• Streamlined workflow
  • For sharing patients across multiple machines on the same database
Radixact® = High Treatment Delivery Efficiency

• Faster image acquisition
  • 10 rpm gantry rotation increased from 6 rpm

• 40% shorter scan time
  • 6 second beam-on warm up decreased from 10 sec

• 15% reduced delivery time
  • 1000 MU/min dose rate increased from 600 MU/min
• **Purpose:** To compare the performance of the new delivery system “Precision” using as benchmark clinical plans generated for TomoTherapy HDA system.

• **Methods:**
  - The TPS “Precision” was commissioned according to the TG-53 recommendations.
  - 10 patients plans were developed to be treated on TomoTherapy HDA system using “VoLO”. The plans were optimized until the Dose Volume Histograms (DVH) and the dose distribution assessed every slice met the clinical objectives.
  - Same 10 patients were replanned for with TPS “Precision” for comparison. The plans were optimized until the DVHs and the dose distributions closely matched those obtained previously.

• **Results:** The TPS “Precision” produced optimized plans substantially faster than its predecessor. The reduction in “on-beam” time for the new plans was 20-50%.

• **Conclusion:** In comparison with its predecessor, the Radixact® planning process was faster and the treatment beam-on time was reduced up to 50% due the increase in output (1000 cGy/min at isocenter).
Average Daily # of Treatments (Mar'17 - Mar'18)

Shorter operating hours for Radixact® than Truebeam™

However, same average # of MCI patients treated PER HOUR!
Radixact® Couch Improvements

- Easier patient setup
  - x-, y-, and z-axes move independently

- Reduced sag
  - A pallet support has been added to the rear of the Radixact Couch to support the weight of the couch as it enters the bore
• **PURPOSE:** To characterize the image quality and assess the stability of Radixact MVCT scans.

• **METHODS:**
  • A cylindrical solid-water phantom (Cheese Phantom) with known density plug inserts and high contrast resolution plug was used
  • Scans were obtained with 3 different pitches: fine, normal, coarse
  • Image quality analysis was performed in the ImageJ software platform (noise level, uniformity, spatial resolution, HU stability)
  • The homogenous region of the phantom was used to evaluate noise and uniformity parameters by placing ROIs in the 4 sectors and peripheral regions of the phantom
  • Each ROI was placed in the same spot on each scan
  • HU stability was studied using the various known density plugs
  • The position of the plugs within the phantom was maintained during each scan
Initial Clinical Evaluation of the Stability of the Radixact® MVCT Image Quality
Usha Robins, Tino Romaguera, Vivek Mishra, Alonso Gutierrez

• RESULTS:
  • All image parameters showed good stability
  • Image noise and uniformity were consistent over time and within the 3 scan types
  • Image noise was 41HU and uniformity was 11HU, within TG148 recommended tolerances
  • A maximum 9HU change was noted in the density plugs (range: 683-678HU)
  • Hard contrast showed consistent detection and was clearly visible in all scans

• CONCLUSION: Radixact MVCT has no significant statistical variation in the noise, uniformity, and HU stability over the 3 month evaluation period.
Improved MVCT Image Quality

- *CTrue* iterative reconstruction algorithm
- Reconstructs CT fan-beam scans with enhanced image quality
- Maintains a low imaging dose and the ability to perform live reconstruction as the images are acquired
- *Much improved signal-to-noise ratio*, which in turn *increases the soft-tissue contrast*
Pelvis

MVCT - Normal

MVCT IR - Normal
Chest

MVCT - Normal

MVCT IR - Normal
Radixact® Case 1

- 63 year old male
- Left tonsil squamous cell carcinoma, p16+
- Tonsillectomy + left neck dissection
- pT2N2b, negative margins, no ECE
- Postoperative radiation therapy
- 60/54 Gy in 30 fractions
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Radixact® Case 2

- 36 year old female
- Multicentric T3N1M0 infiltrating ductal carcinoma of right breast
- Neoadjuvant chemotherapy
- Right mastectomy (pT1cN3a)
- 50 Gy in 25 fractions to right chest wall, supraclav, IMNs
Heart: mean 3.2 Gy
Lungs: mean 12.5 Gy, V20 19%
Radixact® Case 3

• 78 year old female
• Squamous cell carcinoma of the mid thoracic esophagus
• cT3N3M1 (supraclavicular involvement)
• Definitive chemoradiation
• 50.4 Gy in 28 fractions
Follow up

- Resolution of dysphagia
- Acute grade 2 esophagitis
- No grade 3+ toxicity
- Complete metabolic response on PET scan
Radixact® Case 4

- 71 year old male with distended abdomen
- CT scan demonstrated 30 x 23 x 26 cm retroperitoneal mass
- Biopsy positive for liposarcoma
- 45 Gy in 25 fractions to entire tumor
- 55 Gy in 25 fractions to posterior margin
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Follow up

• Acute grade 2 diarrhea
• No grade 3+ toxicity
• Restaging CT scans pending
Radixact® Case 5

- 50 year old female
- Vaginal bleeding
- Squamous cell carcinoma of the cervix
- Radical hysterectomy, BSO, pelvic/PA lymphadenectomy
  - 8.5 cm tumor, positive margin, LVI, 4/9 pelvic LN+, 2/2 PA LN+
- 45 Gy in 25 fractions extended pelvic field
- Vaginal HDR 5 Gy x 3
Radixact® Case 6

- 49 year old female
- 15 cm left adrenocortical adenoma resected in 2011
- 8.3 cm local recurrence resected in 2017 with negative margins
- 45 Gy in 25 fractions
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Follow up

- Grade 1 nausea during treatment
- No toxicity after 1 month
- Restaging MRI shows no evidence of disease
Radixact® Case 7

• 64 year old female
• T1cN0M0 invasive ductal carcinoma right breast
• Status post lumpectomy with negative margins
• 42.56 Gy in 16 fractions using TomoDirect™
Radixact® Case 8

• 59 year old
• Widespread metastatic disease of unknown primary
• Significant back pain not despite medication corresponding to lumbar spine metastasis
• 20 Gy in 5 fractions to L1-L4 using TomoDirect™
Complete resolution of pain after 2 fractions
Radixact® Case 9

• 74 y o female with stage IV (T1N2M1) pancreatic cancer
• Duodenal metastasis causing biliary obstruction
• 30 Gy in 10 fractions using TomoDirect™
CyberKnife® M6™ System
In the Clinic
Why CyberKnife®?

• Submillimeter robotic accuracy and precision
• Versatility
  • Intracranial and extracranial targets
  • SRS, SBRT, or even conventionally fractionated RT
• Dynamic tracking and motion compensation
  • No IGTV = reduced normal tissue dose
• Patient comfort
  • No head frame
  • No need for abdominal compression or breath hold
Why M6™?

• InCise™ MLC
  • 41 leaf pairs
  • 2.5mm @ 80cm
  • FS: 12x10cm²
• InCise™ vs. IRIS™ *
  • Decrease 38±10% MU
• Treatment time reduction
  • 30-45min to 15-20mins

CyberKnife® Fractions Delivered Per Month
CyberKnife® Fractions Per Diagnosis (Mar'17 - Mar'18)

- Brain: 224
- Lung: 235
- Spine: 65
- Lymph Nodes: 19
- Other: 7
- Liver: 30
- Prostate: 5

Miami Cancer Institute
CyberKnife® Case 1

• 70 year old
• Right upper extremity numbness and tingling
• MRI showed left posterior temporal occipital lobe mass
• Lung primary with single brain met
• 9 Gy x 3
CyberKnife® Case 1

• CyberKnife more favorable than GK
  • GK frame not feasible for 3 fractions
  • GK mask not ideal because of the posterior location
CyberKnife® Case 2

• 53 year old
• Stage IIIB colon adenocarcinoma
• Hemicolecetomy then FOLFOX x 6 months
• 6 mm right lower lobe lung met s/p lobectomy
• 14 mm left lower lobe lung met stable on FOLFIRI + Avastin
• SBRT on CyberKnife®
  • 10 Gy x 5
  • Synchrony® Respiratory Tracking System
  • Xsight® Lung
Tumor smaller after 3 months
Patient without side effects
CyberKnife® Case 3

- 66 year old
- Meningioma of right dorsum sella/petrous clinoid ligament with erosion of the clivus with extension into right cavernous sinus
- Presented with diplopia
- 52.2 Gy in 29 fractions
Only grade 1 fatigue

Mild diplopia improvement
CyberKnife® Case 4

• 57 year old male
• 18 month history of personality changes, difficulty concentrating, blurred vision in the left eye
• MRI showed 6.3 cm lesion in left frontal skull base
• Frontotemporal craniotomy and GTR
• WHO grade 1 meningioma
• 10 years later developed local recurrence, 3 cm
• SRS vs. FSRT vs. conventional RT
<table>
<thead>
<tr>
<th></th>
<th>PROTONS</th>
<th>CYBERKNIFE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Max Dose (Gy)</td>
<td>Mean Dose (Gy)</td>
</tr>
<tr>
<td>Hippocampus_R</td>
<td>0.0</td>
<td>0.3</td>
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<tr>
<td>Hippocampus_L</td>
<td>12.7</td>
<td>2.0</td>
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<tr>
<td>Optic Nerve_R</td>
<td>3.1</td>
<td>0.5</td>
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<tr>
<td>Optic Nerve_L</td>
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<td>16.1</td>
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<td>Optic Chiasm</td>
<td>15.8</td>
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<tr>
<td>Brainstem</td>
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<td>Cochlea_L</td>
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<tr>
<td>Pituitary</td>
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<td>12.9</td>
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</table>

DOSE DIFFERENCE
CyberKnife® Conclusions

- Versatility
  - Intracranial and extracranial applications

- Patient convenience
  - Fiducials not required for many patients
  - Treatment time reduced with MLC

- Efficacy
  - High dose conformality
  - Chosen for some of our most challenging cases
Thank you