Concept of Motion Management in Radiation Therapy
(Immobilization, Positioning and Monitoring) : Radiation Technologists Perspectives

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RTT, Radiosurgery Center, Ramathibodi Hospital
• **X-Knife** 1997-2015
  - SRS 377 cases
  - SRT 1355 cases

• **Cyber Knife** 2009
  - SRS 591 cases
  - SRT 1198 cases
  - SBRT 268 cases

• **EDGE** 2016
  - Conventional (IMRT/VMAT) 305 cases
  - SRS 10 cases
  - SRT 60 cases
  - SBRT 86 cases
2 orthogonal KV and intersect the patient symmetrically at 45 degree angle
Stereoscopic X ray (2D/2D, 2D/3D), CBCT(3D/3D), OSMS, Calypso
• We want to deliver maximum dose to tumor cells and minimum dose to surrounding normal tissue

...but

- patient movement
- tumor movement
• Reduce
• Limit
• Gating and Tracking
• The main goal of immobilization is to help reduce patient positioning uncertainties

- Accurately reproduce patient positioning from simulation to treatment
- Inter – fraction : Improve treatment to treatment alignment
- Intra – fraction : Minimize movement during treatment
• Patient-specific considerations and comfort
• Patient training and feedback
• Staff training and involvement
• Doctor request
• Set-up sheet
Intracranial Immobilization
Intracranial Immobilization:

Cyber Knife

Headrest + Baseplate + Thermoplastic mask (2.4mm/full face)
Fix Baseplate with Couch by using Lock Bar
• Common challenges and pitfalls
  - The thermoplastic mask has shrinkage
  - Cyber Knife treatment a long time
    (balance comfort and accuracy)
  - Variety of thermoplastic quality
Patient Setup in Cyber knife: Brain (6D Skull Tracking)
Headrest + H&N Overlay + Thermoplastic mask (Open face) + Bite plate

Intracranial Immobilization: EDGE (SRT/Conventional RT)
Thermoplastic mask (Open face) + bite plate
Intracranial Immobilization: EDGE (SRT/Conventional RT)

Thermoplastic mask (Open face) only

Thermoplastic mask (Open face) + bar
Intracranial Immobilization: EDGE (SRT / Conventional RT)

Child brain or lesion in neck area

Open face mask/white + Head, Neck & Shoulder Vac-loc (Sedation Case)

Open face mask/white + Silverman Q1 Head Support + Accuform + Bite Plate
Intracranial Immobilization: EDGE (SRS/HSRT)

Full face mask (IMRT type) + Customized headrest
Intracranial Immobilization: EDGE

- Marking line on mask (eye, nose) help for set up position
- Divide hair equally
• **Common challenges and pitfalls**
  - The thermoplastic mask has shrinkage
  - Patient understand whole process
  - Pediatric patient
  - Variety of thermoplastic quality
• 1ST day protocol (Simulation)

1) Set Patient from Dicom surface that should be less rotation, translation can move couch

2) Taking image do KV Pair (2D/3D Match) for shift only translation (3D) Rotation less than 0.5 degree

Couch Shift data
• 1st day protocol (continue)

3) Scan CBCT and shift 6D couch (correct all direction error)

4) Capture surface Patient (OSMS) for 6D Reference
5) Level couch rotation to zero degree, take off the mask and reposition by using 6D Reference surface (fix couch translation position)

6) Scan CBCT (2nd) Notified doctor to approve image and acquire couch translation position
Patient Setup for EDGE : Brain Protocol (SRT, Conventional RT)

- **2\textsuperscript{nd}, 3\textsuperscript{rd} day protocol**
  - Set up patient by another therapist and save OSMS error report before scan CBCT
  - Analyze OSMS error data and CBCT to approve surface reference

* Use this surface reference until the imaging error is over threshold
* Threshold for conventional RT is 2mm./1 degree (No couch shift, no reposition)
* After 3\textsuperscript{rd} day, scan CBCT and KV pair each time per week
* The set up (surface) direction was determined from data analysis for less error
- Couch position from planning
- Take KV pair (2D/3D match) and shift translation (3D) for correct large error
- Scan CBCT (1<sup>st</sup>) and shift all direction (6D)
- KV pair (2D/3D match) or CBCT (2<sup>nd</sup>) check residual error
- Scan CBCT (3<sup>rd</sup>) after treatment for intra-fraction error
Inter-fraction Error (Setup Error)

- Open face mask with biteplate
- OSMS
- CBCT (Auto-match)
- 57 cases, 247 fractions

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- Close face mask with biteplate
- Laser
- CBCT (Auto-match)
- 5 cases, 20 fractions

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- Open face mask with biteplate
- Mold care
- OSMS
- CBCT (Auto-match)
- 4 cases, 28 fractions

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**Intra-fraction Error (Before vs After treatment)**

- Open face mask with biteplate
- CBCT before - after
- 57 cases, 165 fractions

- Close face mask with biteplate
- CBCT before - after
- 8 cases, 19 fractions

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- Open face mask with biteplate
- Mold care
- CBCT before - after
- 4 cases, 11 fractions

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• Body motion
• Non-respiratory motion (Volume change of nearby deformable structure)
• Respiratory motion (thorax and upper abdomen)
Extracranial Immobilization: CyberKnife (spine)

C1-C3: mask
C3-C7: mask + Vac-bag

Other (T/L-S Spine): Full Body Vac-bag
• Fix Vac-bag with couch by using lock bar
• Mark on device
• **Common challenges and pitfalls**
  - The thermoplastic mask has shrinkage (C-spine)
  - Cyber Knife treatment a long time (balance comfort and accuracy)
  - Separation of organs that do not want to enter the treatment field
  - Asymmetry of Vac-bag
  - Collision
  - Limit bore CT or bore MRI
  - Leaking Vac-bag
Patient Setup for Cyber Knife: Spine (Spine Tracking)

- Perform small-image registration at 81 points at the intersection of a rectangular grid
- Adjust grid size to cover bony area more than soft tissue
Extracranial Immobilization

Lung, Liver (SBRT)
Respiratory motion management

- Forced shallow breathing with abdominal compression (FSB) shallow breath, 4DCT
- Respiratory Gating
  - Real-time Position Management (RPM) Marker movement surrogate, Free breath- 4DCT or Self-Breath hold
  - Active-Breathing Control (ABC) Air capacity breath hold
  - Optical-based system (OSMS...) Surface movement surrogate, DIBH
- Tumor tracking
  - Real-time localization, Fiducials, Calypso, gating
  - Real-time beam adaptation Synchrony, Fiducials , CK tracking
• Forced shallow breathing with abdominal compression (FSB) shallow breath, 4DCT

• Respiratory Gating
  • Real-time Position Management (RPM) Marker movement surrogate, Free breath- 4DCT or Self-Breath hold
  • Active-Breathing Control (ABC) Air capacity breath hold
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• Tumor tracking
  • Real-time localization Fiducials, Calypso, gating
  • Real-time beam adaptation Synchrony, Fiducial , CK tracking
Extracranial Immobilization: CyberKnife (Lung, Liver)
Extracranial Immobilization: Cyber Knife (Lung, Liver)

- >3 Fiducials placement 1 week
- Before Immobilization and CT-scan
- Using Full Body Vac-bag and
- Patient wear Synchrony vest
- Synchrony vest attach optical markers
Extracranial Immobilization: Cyber Knife (Lung, Liver)

• Fix all devices (Baseplate, Vac-bag) with Couch by using Lock Bar
• Mark on device
• Common challenges and pitfalls
  - Cyber Knife treatment a long time (balance comfort and accuracy)
  - Separation of organs that do not want to enter the treatment field
  - Choose a Synchrony vest to fit the patient
  - Collision
  - Asymmetry of Vac-bag
  - Patient training
  - Limit bore CT or bore MRI
**Synchrony tracking**

- Synchronizes treatment delivery to the motion of the tumor throughout the respiratory cycle
- Continuously tracks the internal movement (Fiducial) via external movement (Breathing pattern) and compensates by using the robot (Correlation model)
• Forced shallow breathing with abdominal compression (FSB) shallow breath, 4DCT

• Respiratory Gating
  • Real-time Position Management (RPM) Marker movement surrogate, Free breath- 4DCT or Self-Breath hold
    • Active-Breathing Control (ABC) Air capacity breath hold
    • Optical-based system (OSMS...) Surface movement surrogate, DIBH

• Tumor tracking
  • Real-time localization Fiducials, Calypso, gating
  • Real-time beam adaptation Synchrony, Fiducial, CK tracking
• Patient tolerance may be vary so make sure that the selected technique (and motion management) is suitable for each patient
• Patient understanding of the crucial of the whole process
• Self-breath hold technique heavily depend on patient, need confirmation and practice (> 20 seconds)
  - Lung -> Breath-hold > 20 sec -> RPM + inhale BH(lung volume)
  - Liver -> Breath-hold > 20 sec -> RPM + exhale BH(less move)
  - Breath-hold < 20 sec -> FSB + 4D CT(limit movement)
Mahidol University
Wisdom of the Land

SBRT System
Body Pro-Lok SBRT

Full(Long) Vac-Lok

Short Vac-Lok+Knee fix

Respiratory Belt

Clam-Lok cushion

Respiratory Plate
Vac-Lok cushions are custom formed for patient comfort and positioning accuracy, supporting all parts that have effect with lesion.

Marking on immobilization that relate with the patient body marks.
• Common challenges and pitfalls
  - Collision
  - Compact device
  - Balance between comfort and accuracy
  - Patient understanding and co-operative of the whole process is important
  - Asymmetry of Vac-bag
  - Position of lesion
  - Skin mark
  - Leaking vac-bag
Immobilize + Compression belt + RPM 4DCT
Immobilize + RPM (Self breath hold)
Dry run

• To make sure that nothing will be hit during imaging and treatment
• To find out that move to center couch is need or not
• Set up position by using mark on device and body, add pressure in belt, move couch position from planning and dry run.

• Take KV pair (2D/3D match) for alignment and shift couch (3D) reduce large error (reposition if rotation error is too much).

• Scan CBCT (3D/3D match) and shift couch 3D or 6D then check by doctor, scan CBCT (Spotlight) again for check position.
Patient Setup for EDGE : SBRT (Breath hold technique)

- Set up position by using mark on device and body, put RPM block, move couch position from planning and dry run.
- Take KV pair (2D/3D match) when patient breath hold for alignment and shift couch (3D) reduce large error.
- Scan CBCT (3D/3D match) when patient breath hold and shift couch 3D or 6D then check by doctor, scan CBCT (Spotlight) again for check position.

RPM Block
Treat, Self Breath hold + RPM
Calibration RPM
1.> Service mode
2.> PVA calibration
3.> optical camera calibration
Compression Belt (FSB)
- lung
- Compare start couch position with treat couch position
- 40 cases, 197 fractions

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Breath hold
- lung
- Compare start couch position with treat couch position
- 7 cases, 17 fractions

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### Compression Belt (FSB)
- Lung
- CBCT before – after (Auto-match)
- 15 cases, 77 fractions

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### Breath Hold
- Lung
- CBCT before – after (Auto-match)
- 7 cases, 17 fractions

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Calypso - Beacon

CALYPSO®

Beacon® Care Package
For Prostate and Prostatic Bed

Quantity: One (1)

Package Includes: Implantable Beacon®
Transponder and Introducers (3 each)

CAUTION: US federal law restricts this device to
sale by or on the order of a physician.

Varian Medical Systems – Worldwide Headquarters
3100 Hansen Way, Palo Alto, CA 94304, U.S.A.

Varian Medical Systems
2101 4th Avenue, Suite 100
Seattle, WA 98121, U.S.A.
1-888-VARIAN or 650-213-1000

CE 0086

ASW0094-003
Calypso, Real-time localization

[Diagram showing the Calypso 4D Localization System with labeled components: Optical targets, Implant Beacon Electromagnetic Transponders, 4D Console, Infrared Cameras, Optical System, 4D Tracking Station.]
Calypso, Real-time localization