Immobilization and patient positioning

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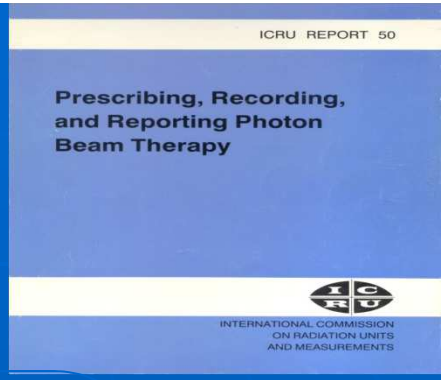
PRECISION RADIOTHERAPY

- State of Art Equipment with MLC's and microMLC's
- Complex treatment techniques –3DCRT,IMRT/IGRT, SRT/SRS
- Extensive use of Imaging Modalities – CT, MR, PET-CT
- Delineation of Volumes - protocols
- Networking environment
- Advanced Planning Systems- 3D, MC Algorithms
- Image guidance with KV or MV cone beam CT
- Electronic Portal Imaging (EPID) for verification

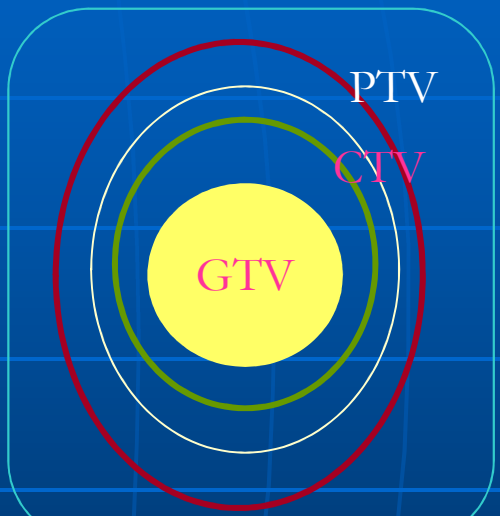
- Best possible Immobilization

Clinical Target Volumes

ICRU50



- GTV - Gross Target Volume
  includes tumor that can be seen in treatment planning images (typically CT, MR or PET).
- CTV - Clinical Target Volume
  includes the GTV plus regional lymph nodes and tissue adjacent to the GTV that may contain microscopic tumor cells.
  The CTV is what the physician wants to treat.
- PTV - Planning Target Volume
  includes CTV plus a margin of healthy tissue to account for inter- and intrafraction organ motion and set-up. In order to treat the CTV, the planner must design a treatment plan for the PTV.



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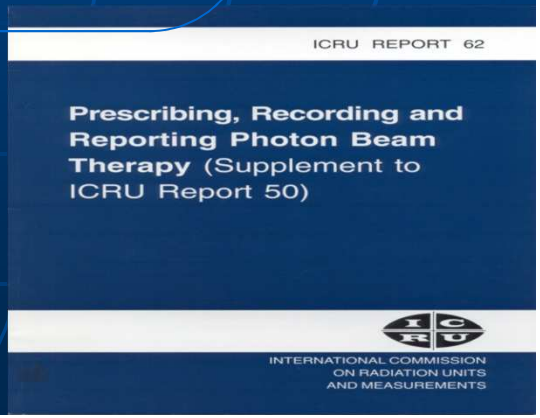


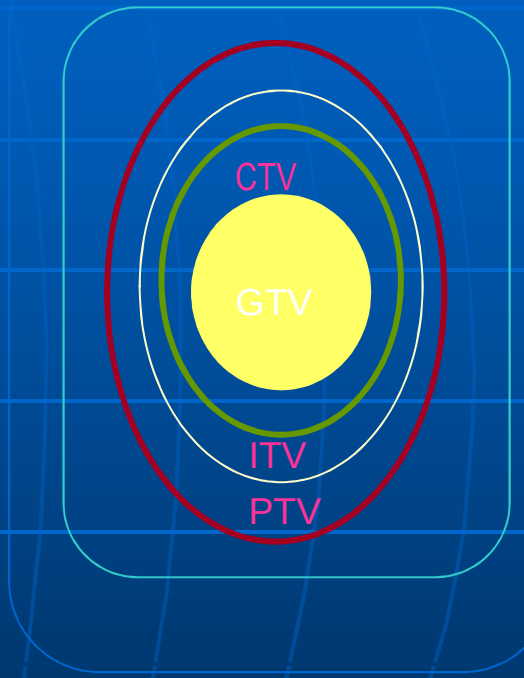
Margins in high precision RT

- Geometric margin (PTV) depends upon: set up errors and organ motion.

- PTV = Internal Target volume (ITV) + Set up margin (SM)
- Internal target volume (ITV): CTV + Internal motion
- Set up margin (SM): margin for set up uncertainties

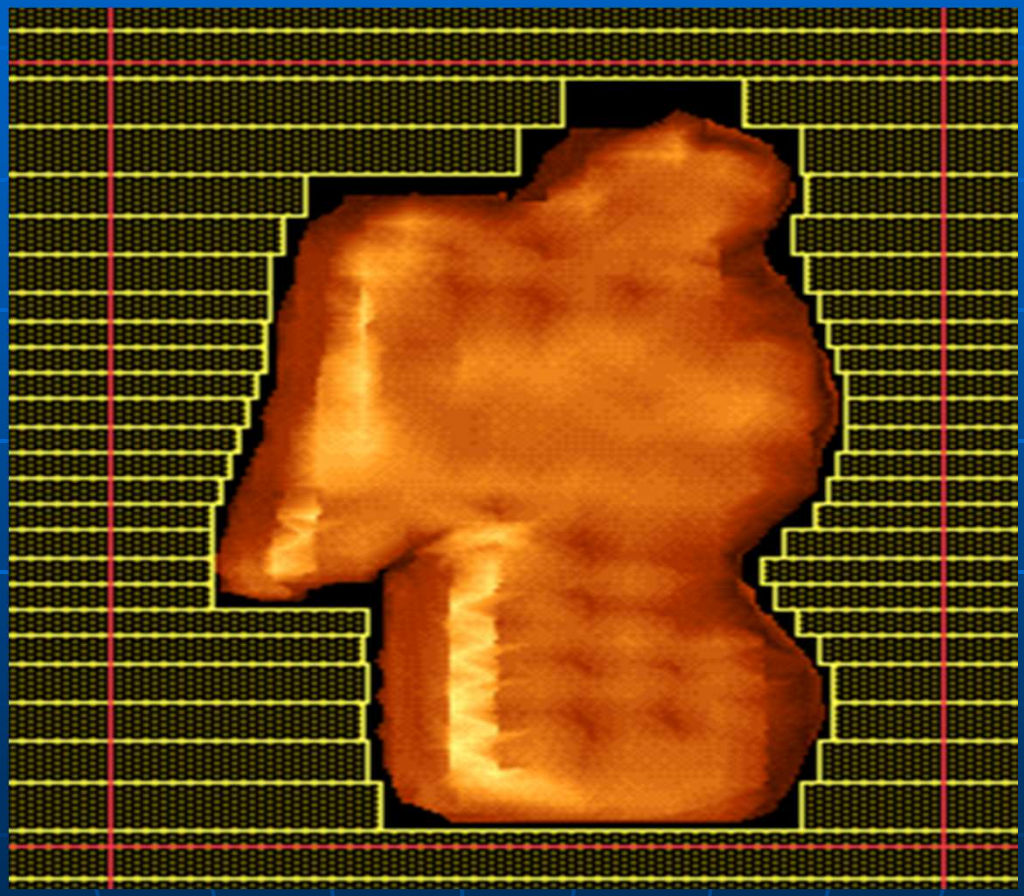
- ITV: reduced by organ motion tracking
- SM: reduced by more accurate immobilization

- PTV margin reduced by: accurate immobilization & organ motion tracking



ICRU 62

CONFORMING THE PTV WITH MLC



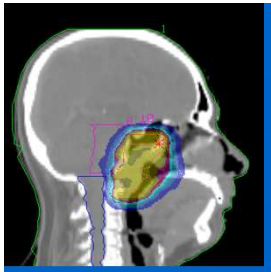
Need of accurate Immobilization!

PITFALLS

As we move from standard treatment to conformal treatment

- Due to more accurate localization with above modalities, the field sizes (margins) have reduced considerably
- Further, due to MLC's irregular shaped conformation became easily possible
- Volume delineation protocols defined different regions within the target and a differential dose to these is possible

This has made the Immobilization during day to day delivery very much important



Immobilization

Proper immobilization: basic but very important step for high precision RT

Types

- Plaster of Paris cast
- Thermoplastic shells
- Perspex shell
- Acrylic shell
- Stereotactic frame
- Vacuum bags

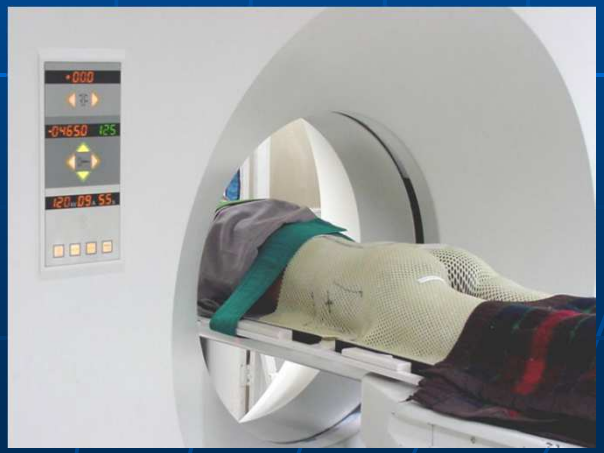
POSITIONING: Simple in-house devices

- Inform patient about immobilization
- Comfortable positioning

1. Knee Rest- comfortable, relaxes back against flat couch
2. Ankle rest-change in foot-change/rotation bony reference points
3. Belly board- takes small bowel away from radiation field by gravity
4. Head rest-pillow:- relaxes strain on neck, comfortable

POSITIONING

- Intention
  - comfortable
  - reproducible
- treatment delivered with optimal sparing of normal tissues
- **Supine/prone (site specific)**
- **Head rest/knee rest /Breast board/rubber traction and other accessories (institution protocol)**
- **Arms above/below**
- **Documented in patient file**
- **Generally finalized in simulator/CT simulator**



SUPINE

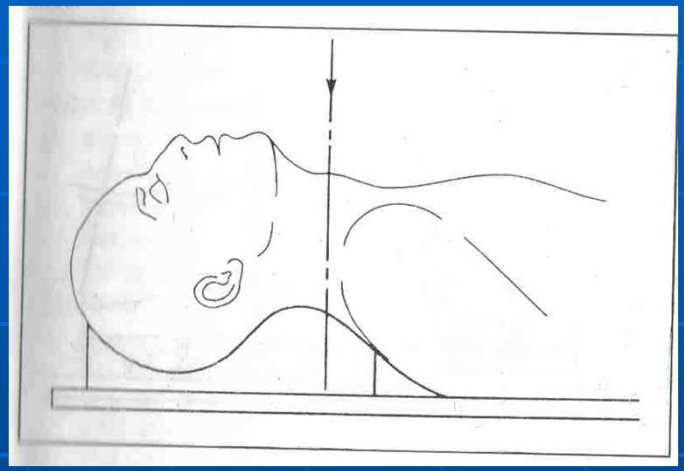
SUPINE POSITION

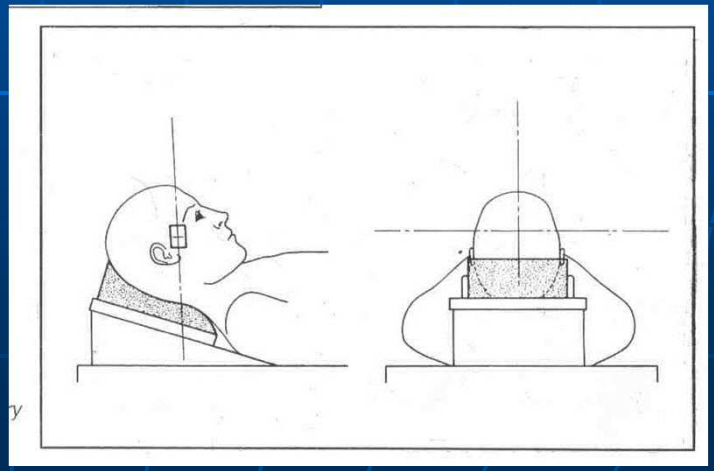
- Commonest position
- Easier, comfortable, easily reproducible
- Hands on chest, head on pillow, legs straight
- FROG leg position:- groin skin folds, low 1/3 vaginal tumours

Possible disadvantages of SUPINE POSTION

- **Obese patient:-skin marks on ant skin-shift by several centimeters-poor reproducibility!**
- **skin folds –more chances of skin reactions**
- **straps, tapes can be used to decrease skin folds- variation/ slipping intra & interfraction!**
- **This causes variation in thickness-non uniform dose**

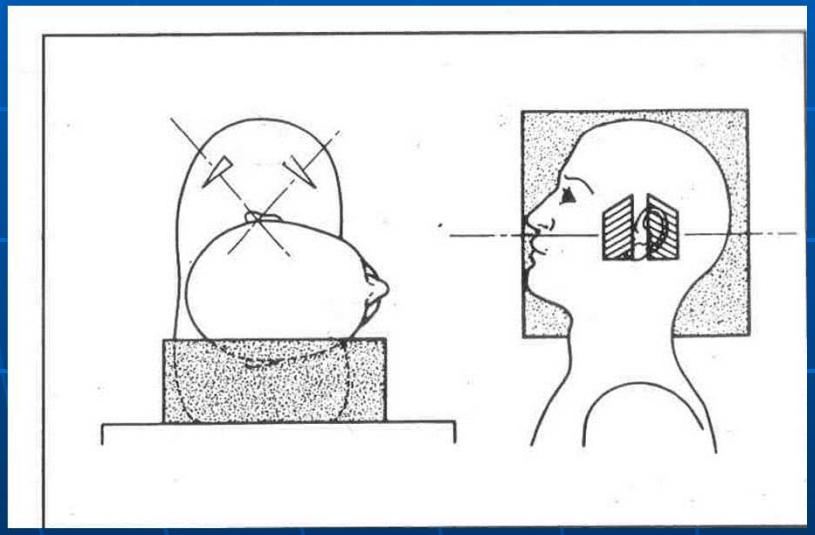
1.



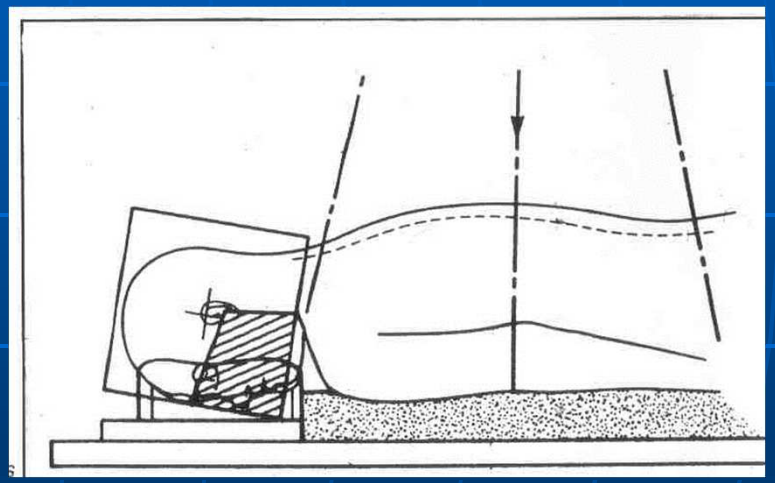


POSITIONING
LATERAL AND PRONE

LATERAL – MID EAR



PRONE - MEDULOBLASTOMA



PRONE POSITIONING
RECTUM

- BELLY BOARD

Principle: gravitation pulls small bowel into hollow cavity – bowel sparing

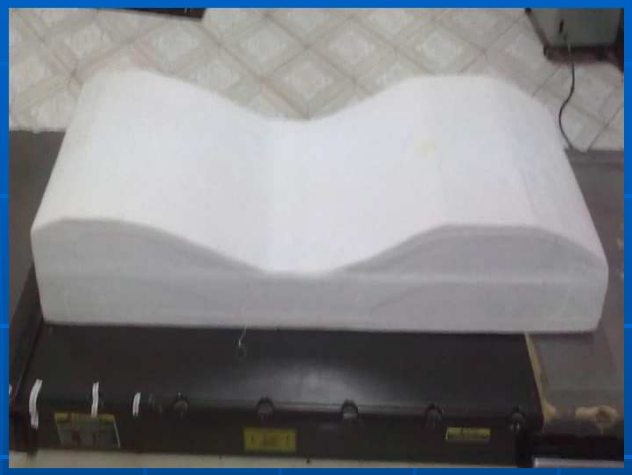
Pros and cons

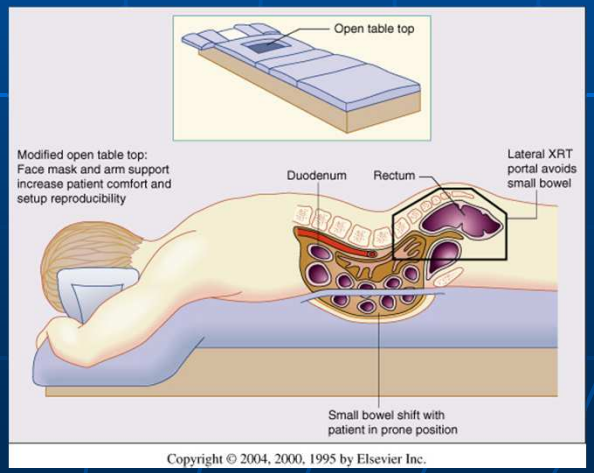
I. Good abdominal muscle tone- less effective

II. Thin patients benefit equally as fat patients

III. In obese patients it's the skin fold ,fat –falls into hollow not small bowel!

IV. Compression roll under pelvis





BREAST POSITIONING

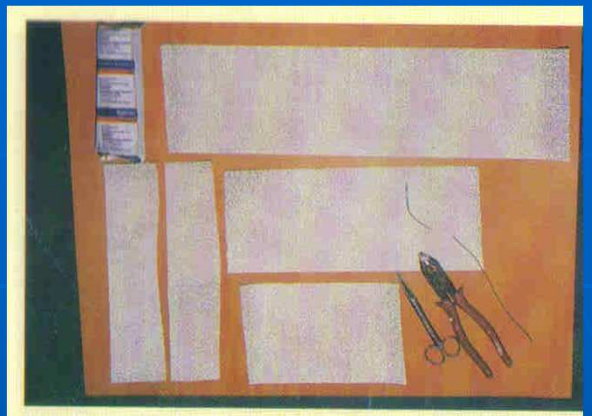
PERSPEX BREAST BOARD

THERMOCOL BOARD

LINAC BREAST BOARD

Plaster of PARIS Moulds

- (CaSo4)2.H2O
- POP Bandages as per size (6” wide)
- Vaseline the surface
- Use rubber Traction as appropriate
- Wrapped and positioned over face as per marking
- Use Aluminum wire at border/junction
- Moulds by itself when dried
- Simple, inexpensive, preliminary form of immobilization



POP strips & instruments for preparation of POP mould

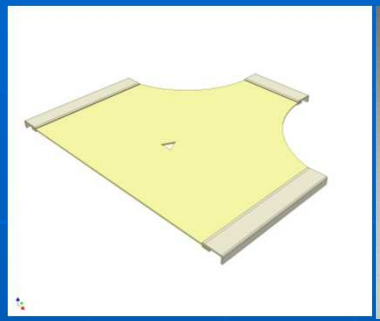
PERSPEX & ACRYLIC MASKS

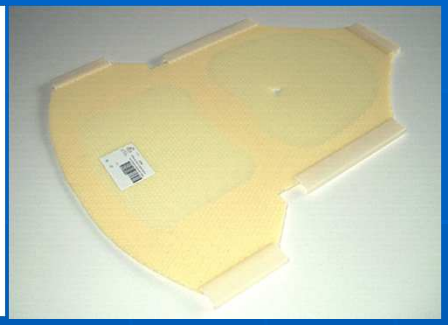
- POP negative mask
- Dental stone cast or bust is made from this
- Mix (paste) of acrylic powder and cold cure liquid is spread uniformly on the cast
- Acrylic shell thus formed is removed after appropriate time
- Alternatively the bust is use to form Perspex moulds with sheets of 2-3 mm using a vacuum forming machine
- Both these techniques are time consuming and are now almost replaced by thermoplastic

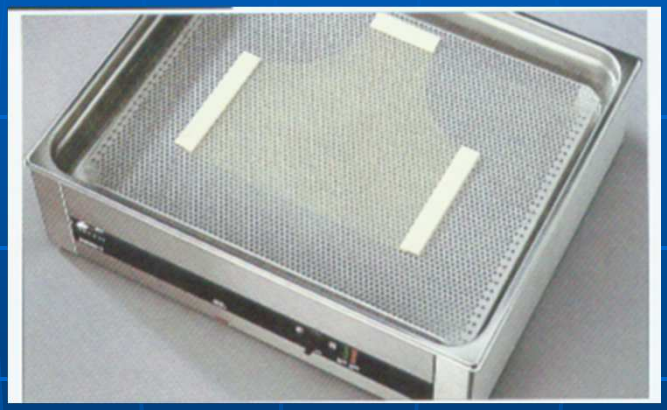
Kalstone cast for acrylic mould

Completed acrylic mould

THERMOPLASTIC MASKS

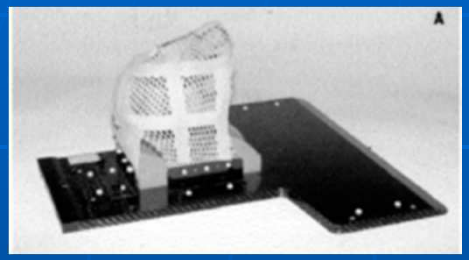




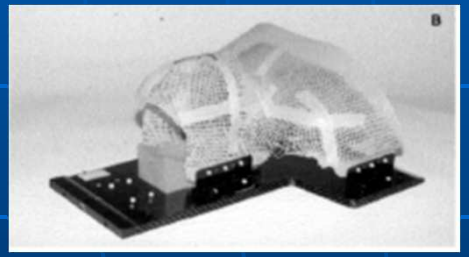


-Thermoplastic sheets in various sizes & suitable for various sites
-The water bath maintaining ~70° C
-The sheets get malleable at this Temp.
-Wrapped over area of interest carefully
-Appropriate markers put during simulation

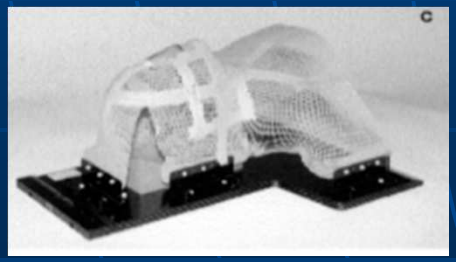
Thermoplastic mask and neck-rests



3-Clamp



4-Clamp



5-Clamp

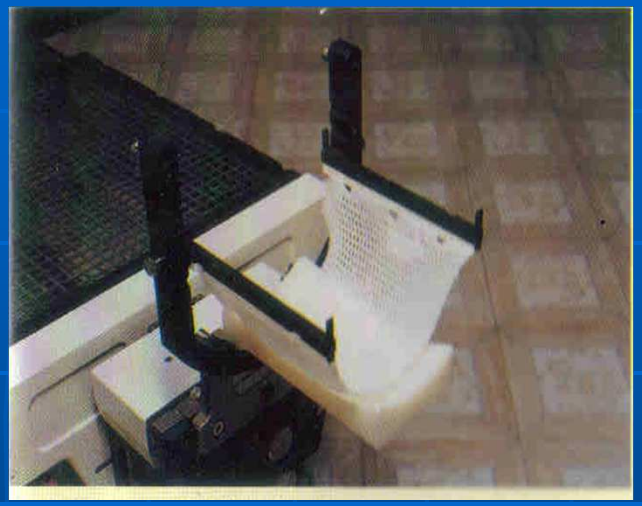
Supports for immobilization of neck

Natural position preferred in head and neck cancer

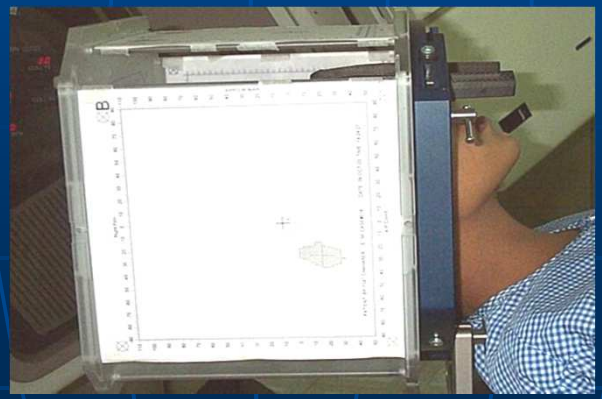
Set up error varies with different head support

STEREOTACTIC IMMOBILIZATION

SPECIAL SRT THERMOPLASTIC MASK

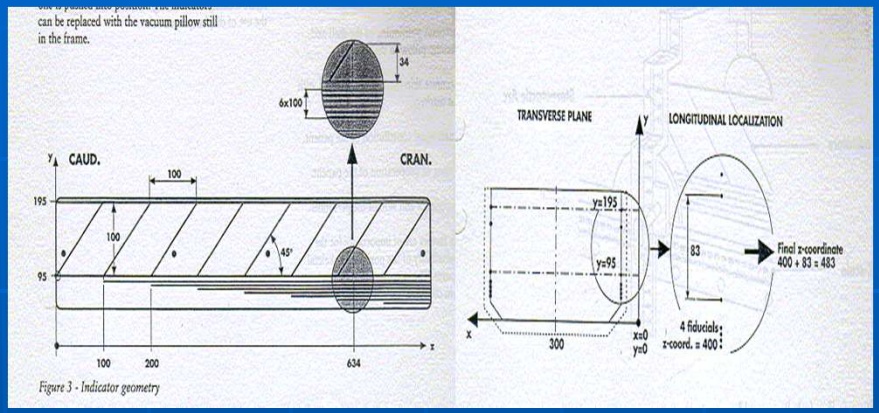


SRS POSITIONING BOX



VACCUM BODY BAG AND STEREOTACTIC BODY FRAME


Vacuum cushion for patient immobilization

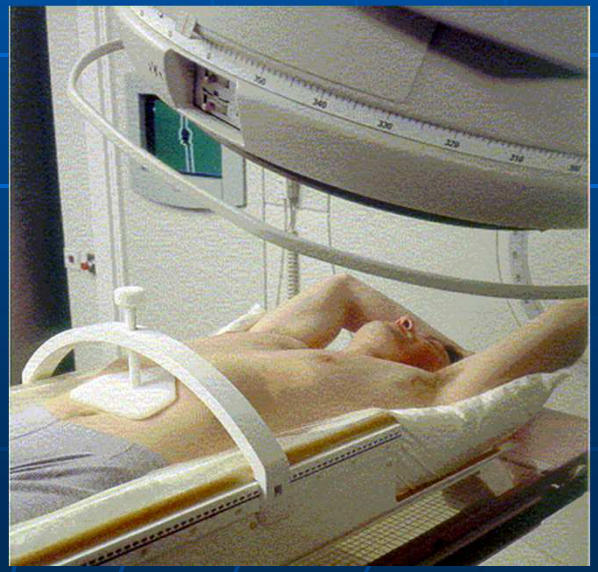


Contains pre-expanded polystyrene micro-spheres

Upon vacuum they pulls together tightly and bag/cushion becomes rigid, retaining shape of body

The body frame has fiducial along both sides for accurate planning & set up

It also has diaphragm control to minimize Respiratory movement



COMMERTIAL ADVANCED SOLUTIONS

INDEXED COUCH AND BASEPLATE

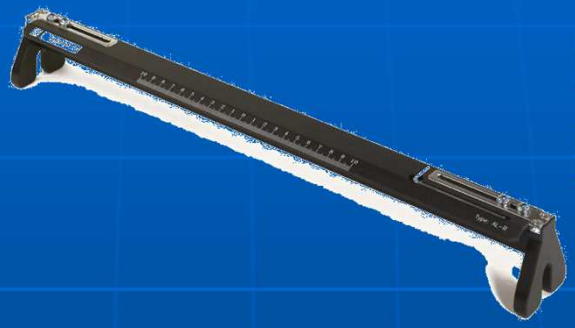
ORFIT LUNG & BREAST BOARD

ORFIT BELLY 7 PELVIS BOARD

PATIENT TRANSFER SYSTEM -CIVCO

MEDTECH

CIVCO



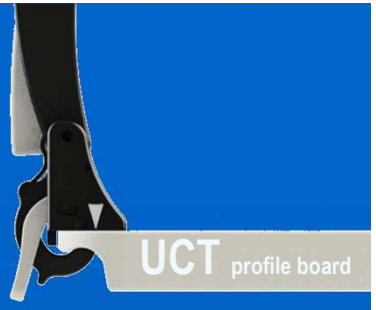
Body Pro-Lok™

- Dedicated Respiratory Belt option

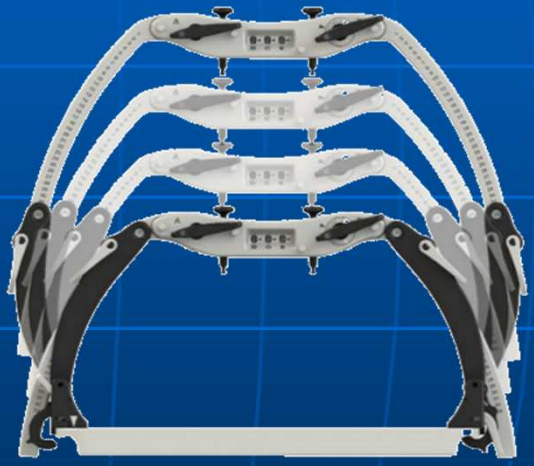
- 3 different sized bridges for different patient sizes
- 210cm Carbon Fibre or 142cm Kevlar platform

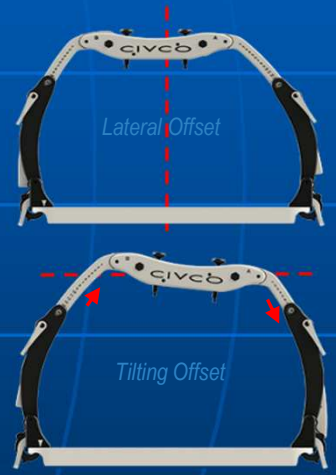
V

Body Pro-Lok ONE™



- Dedicated Respiratory Belt option





- ONEBridge™ uniquely fits all patient sizes with Lateral & Tilting Offsets
- 183cm lightweight Kevlar ONEPlatform™ has 3 lateral offset options

CIVCO SBRT **Motion Management** Systems

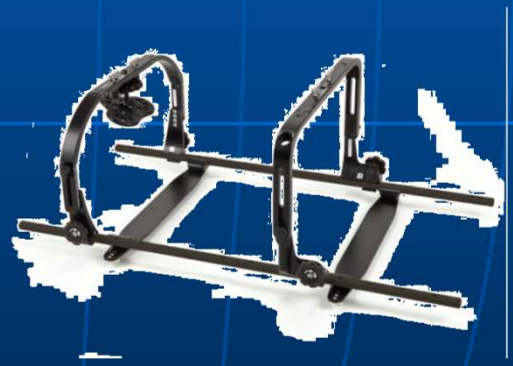
Body Pro-Lok ONE™ System + ONEPlatform™

Body Pro-Lok ONE™ System *n existing* Universal Couchtop™ Long Extension

OVERLAY OPTION: can be used on any couchtop

NO OVERLAY OPTION: specific to certain couchtop indexing systems

Body Pro-Lok™ System + Platform



Body Pro-Lok™ Rails-Only System

Pros & Cons of Using Overlays

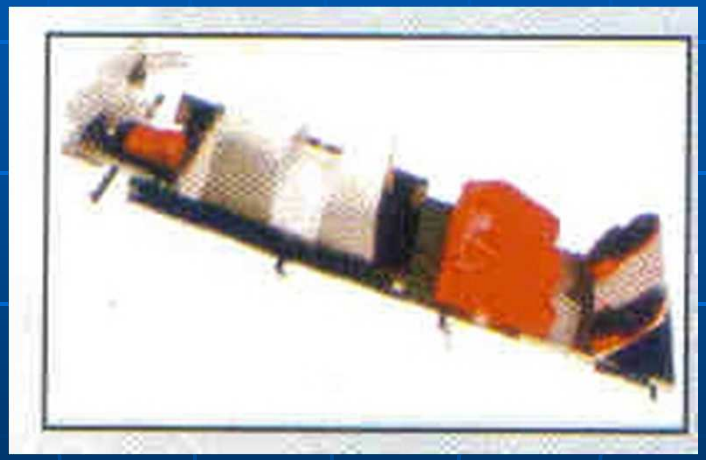
PROS:

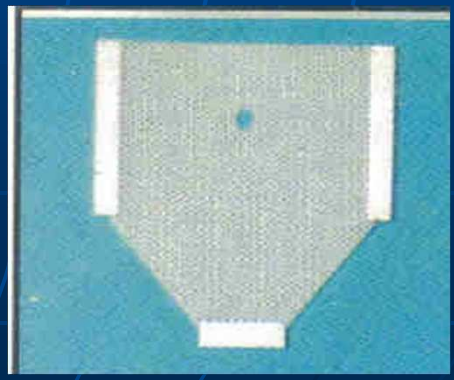
- Standardisation – allows easy matching between all couchtops with simple connection with standard Lok-Bars
- Allows for greater lateral offset if needed.

CONS:

- Adds attenuation
- Requires more dose calculations
- Can be unwieldly to move between rooms
- Requires more storage space.

SAXONS





In-house

Breast Board

Arm Rest

Belly Board

Knee Rest

Perspex Vs Thermoplastic mask

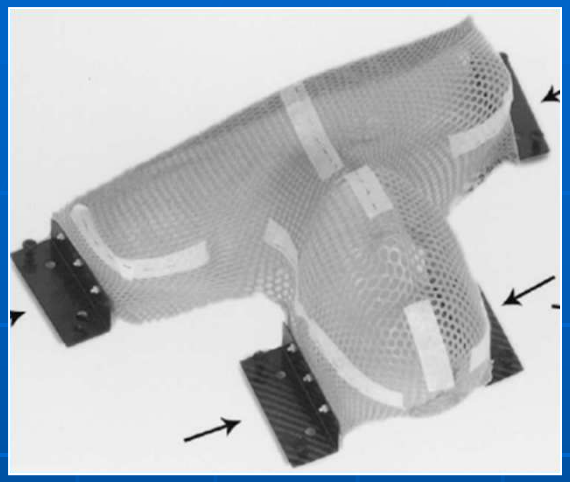
Mask type	Anteroposterior		Cranio-caudal	
	SD (mm)	% deviations > 4mm	SD (mm)	% deviations > 4 mm
Plastic (cut out)	2.2	5.1	2.4	10
Plastic (intact)	1.7	3.1	1.8	2.6
Orfit (cut out)	2.2	9.2	2.3	9.4
Orfit (intact)	1.9	3.3	1.8	2.7

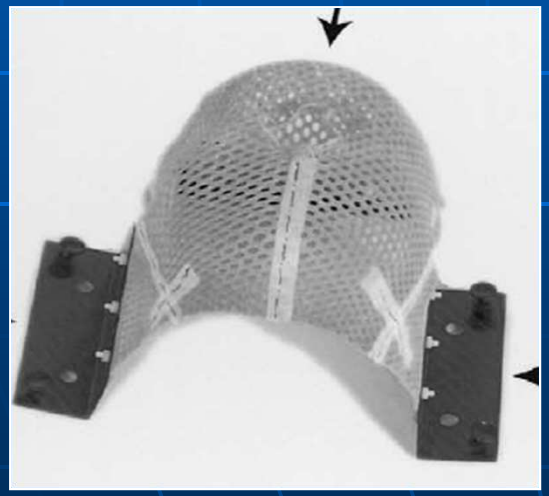
- Randomized study
- Four arms:
  1) Plastic orfit cut
  2) Plastic orfit no cut
  3) Thermoplastic orfit cut
  4) Thermoplastic orfit no cut
- 43 pts of ENT tumours
- Error estimated with 2D EPID

No difference in set up errors

Weltens IJROBP 1995

3 clamp versus 4 clamp mask





Randomized study.

- n= 241 (3 clamp:120; 4 clamp: 121)
- Port films compared manually

	3 clamp vs 4 clamp	
	Absolute difference (mm)	*P-value*
Field shift (1st Week)	-6.0	0.22
Field shift (4th Week)	-1.8	0.69
Any field shift	-4.4	0.45
Field shift related to mask	-0.2	0.97

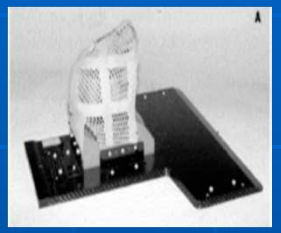
Smaller mask : No compromise in setup reproducibility
Shoulder immobilization and movements: an issue

Sharp L et al; IJROBP 2

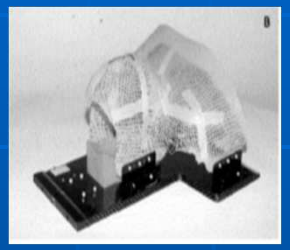
Errors with different fixation devices

Randomized comparison of set up error between 3, 4 & 5 clamp mask (N=30)

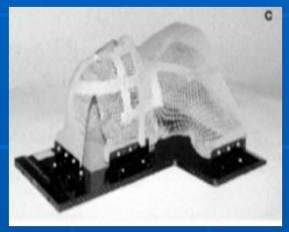
- Setup uncertainties : 2-5 mm in AP, CC or ML directions



3 Clamp



4 Clamp



5 Clamp

	Systematic 3D error mean (SD)			Random 3D error (mm)		
	Head	Neck	Shoulder	Head	Neck	Shoulder
3 Clamp mask	3.1 (1.0)	2.3 (0.8)	2.5 (1.2)	0.7	0.9	2.3
4 clamp mask	2.4 (0.8)	1.7 (1.0)	3.7 (1.1)	0.9	1.0	0.8
5 clamp mask	2.4 (0.9)	2.2 (1.0)	2.8 (1.1)	1.0	1.0	1.2

Gilbeau et al, Radiother Oncol 2001

Organ Motion

Organ motion often is categorized as follows:

- **"Interfraction"** motion occurs between fractions and primarily is related to changes in patient setup daily.
- **"Intrafraction"** motion occurs during fractions and primarily is related to respiration, cardiac motion, and the digestive system.

Varian Clinac® with On-Board Imager™

Inter-fraction / Intra-fraction movement

Intra-fraction error

- Deviation observed within a single fraction of fractionated therapy.
- Caused by random / periodic patient movements (eg. Breathing).

Inter-observer variation

- Due to manual matching of a reference image and a portal image can also introduce substantial measurement errors.

How To Limit Motion?

- Simple techniques

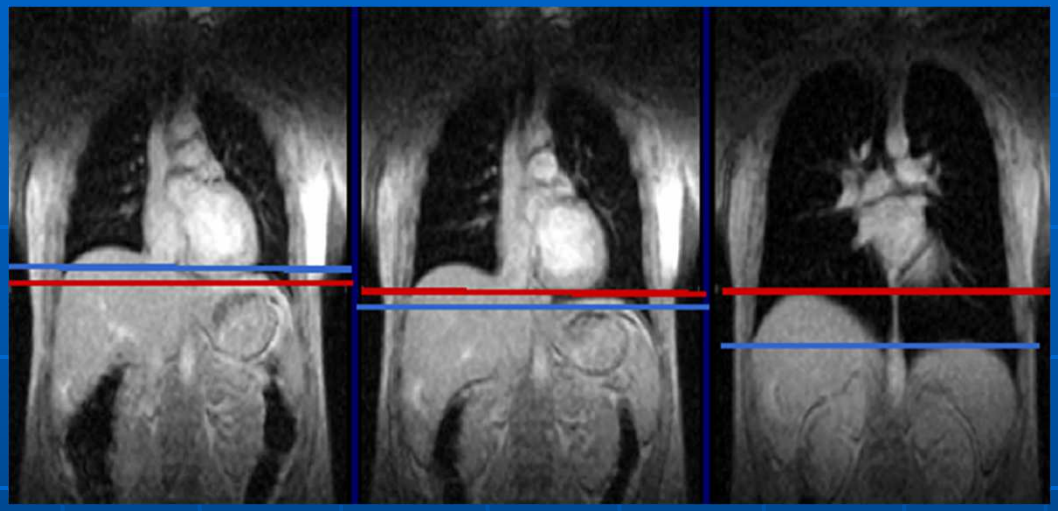
1. Patient immobilization (molds, casts, etc)
2. Breath control
   (Breathing Training)
3. Abdominal compression.
4. Beam gating
   (observation of chest wall motions)

- Complex techniques

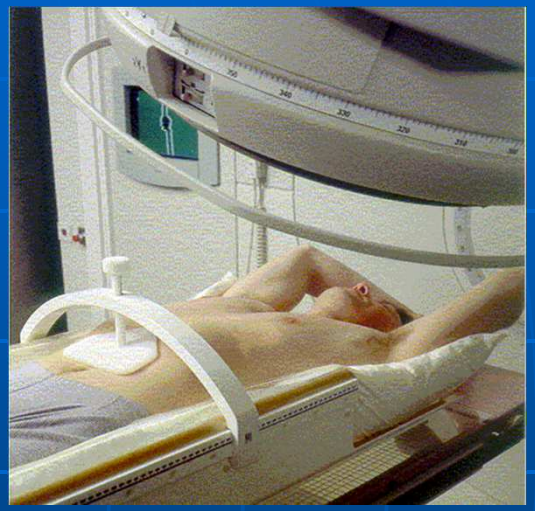
1. Deep Inspiration Breath Hold
2. Active Breathing Control (ABC)
3. Real Time Tumor Tracking
4. IGRT (respiratory gating and real time position management)

Organ Motion Control

Deep Inspiration Breath Hold

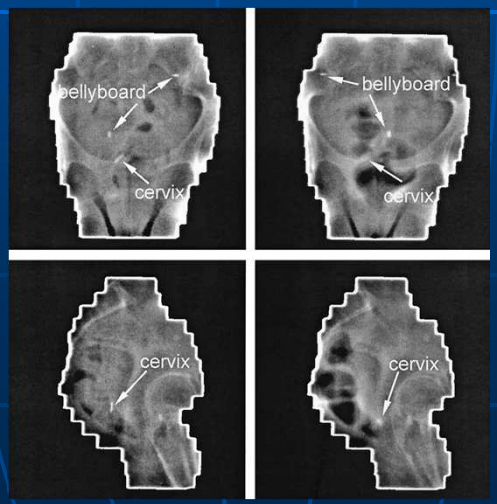


Abdominal Compression



Active Breathing Control

Real Time Tumor Tracking



Respiratory Gating

Electronic Portal Imaging Device (EPID)

- 1980s…. *Norman Baily*
- Commercial EPIDs in 1990s

Types of EPID

- Liquid ionization chamber based
- Camera based
- Amorphous silicon based

Advantages of EPIDs

- Images available immediately
- Images can be used for online correction
- Digital images: can be enhanced by changing contrast and brightness
- Used for matching with DRR image.

KV CT: On-Board Imager (OBI)

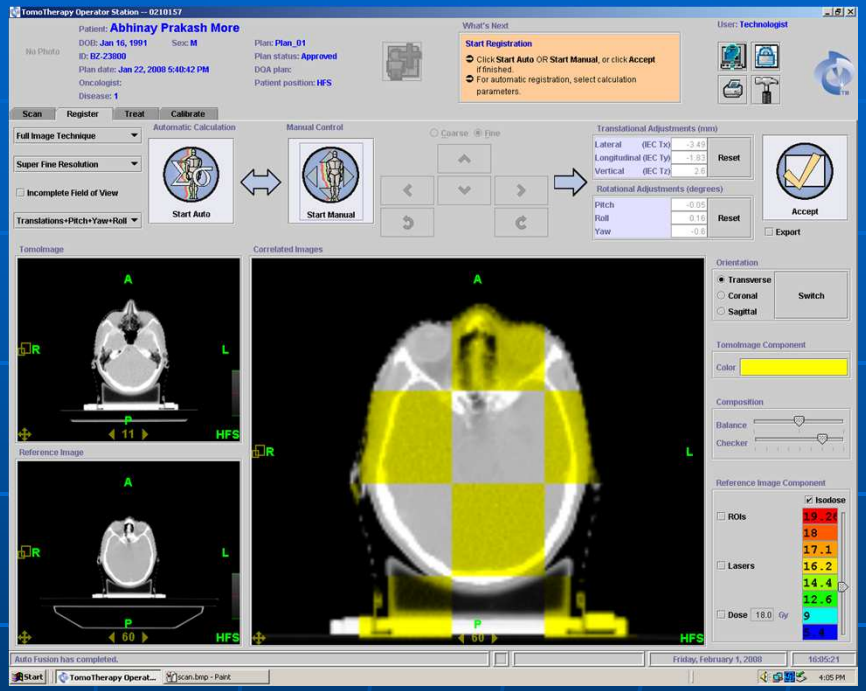
Treat what you have planned

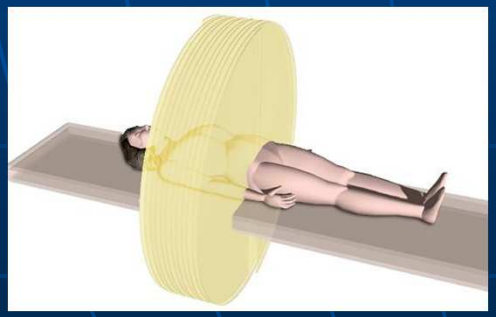
providing the ability to deliver more accurate treatment with confidence and repeatability

High quality Imaging.
Low dose to patient (< 4cGy)
Choice of imaging modalities
Easy-to-use user interface with automated comparison tools
Automated extension and retraction of OBI

Matching with soft tissue delineation

MV CT: Tomotherapy



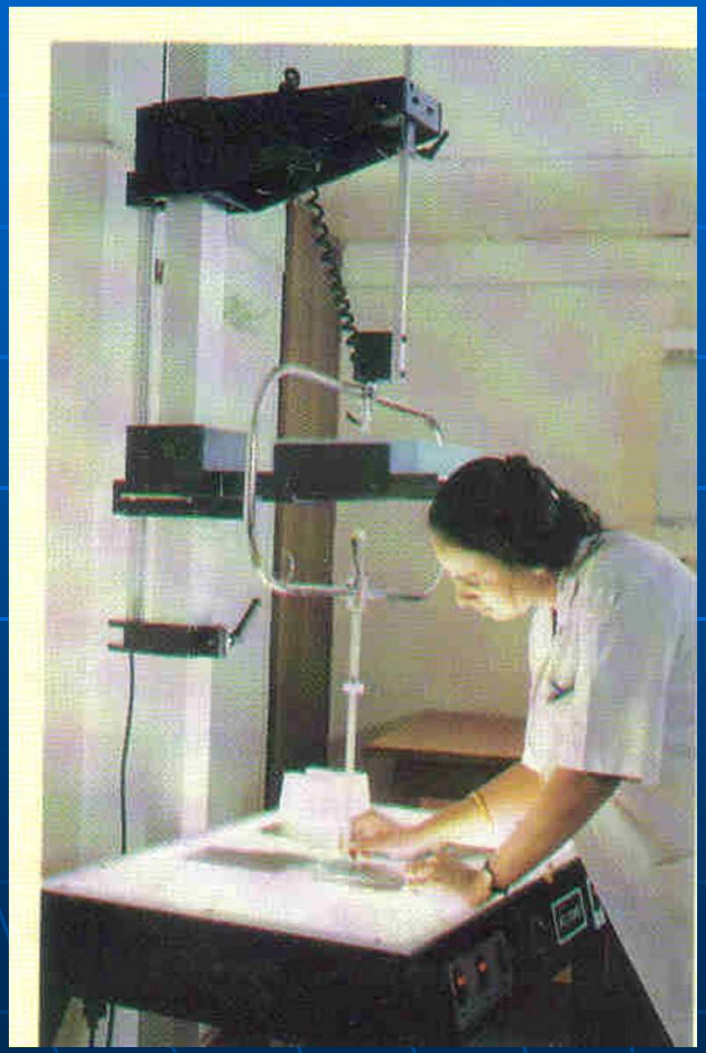


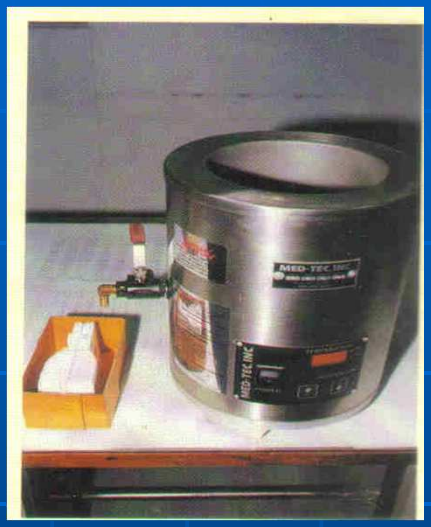
MV CT based contour matching

Mould Room Techniques

- Immobilization Masks
- Conformal Blocks
- Electron Cutouts
- Tissue Compensators
- Oral Prosthesis
- Brachytherapy Moulds

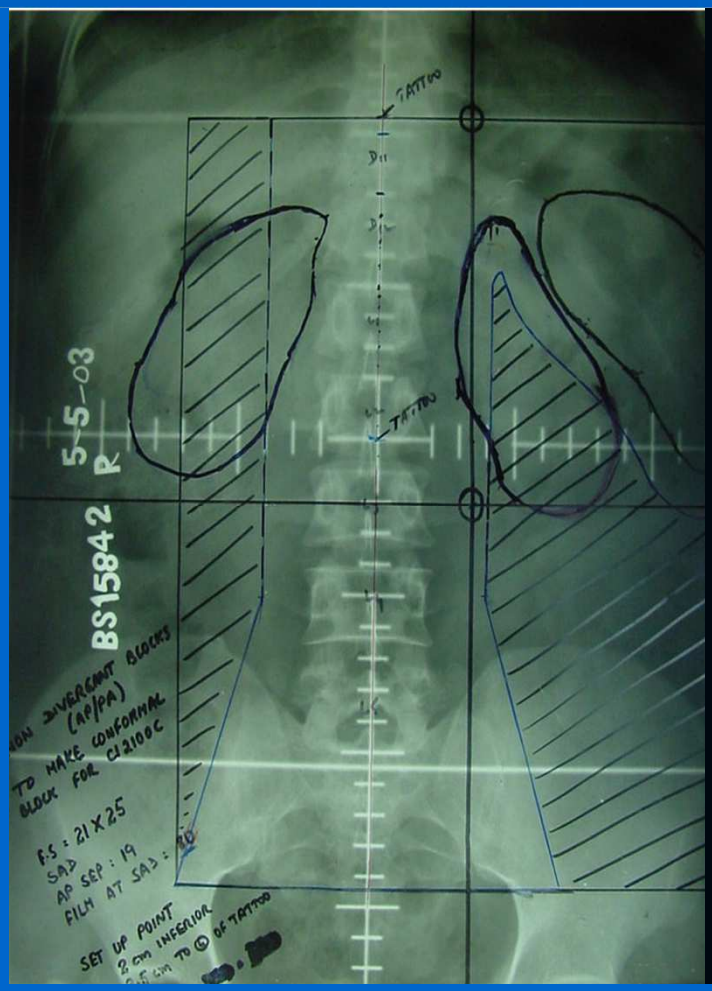
Styrofoam cutter and customized blocks





Low melting alloy, ϱ - 9.3 gm/cc
Ostalloy- Bi-50%, Pb-25%, Cd- 13%, Tin-12%

Conformal block: size depends on distance



TFD

blk

3D Styrofoam cutter - Milling machine

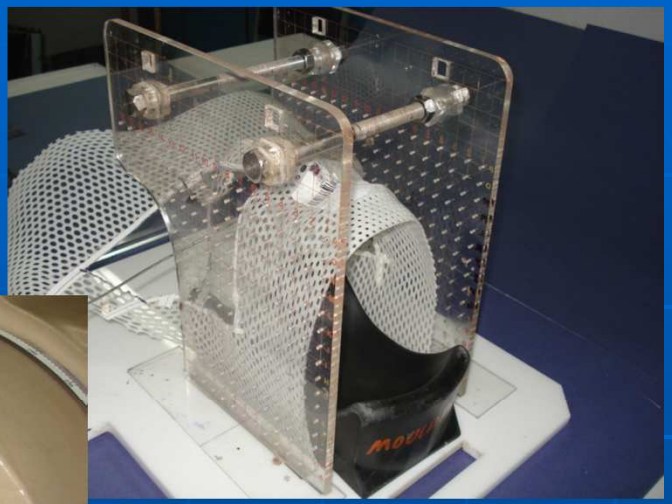
Milling machine with milled block

- *one can export just the fluence to MM's computer & it can also convert it into compensator thickness file*

Aluminum blocks Tissue Compensator

JIG

Treatment

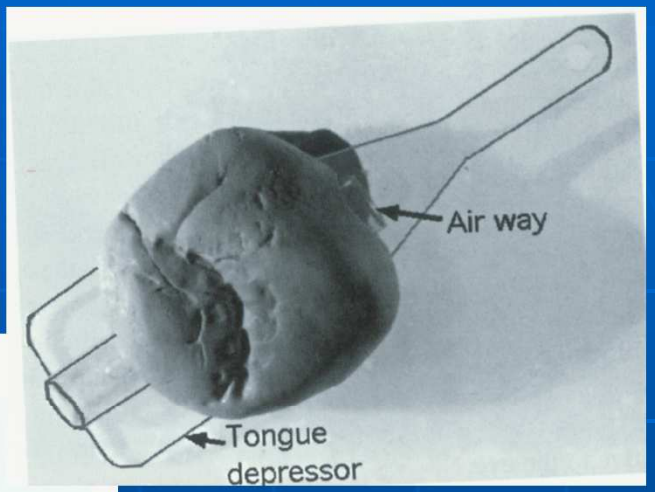


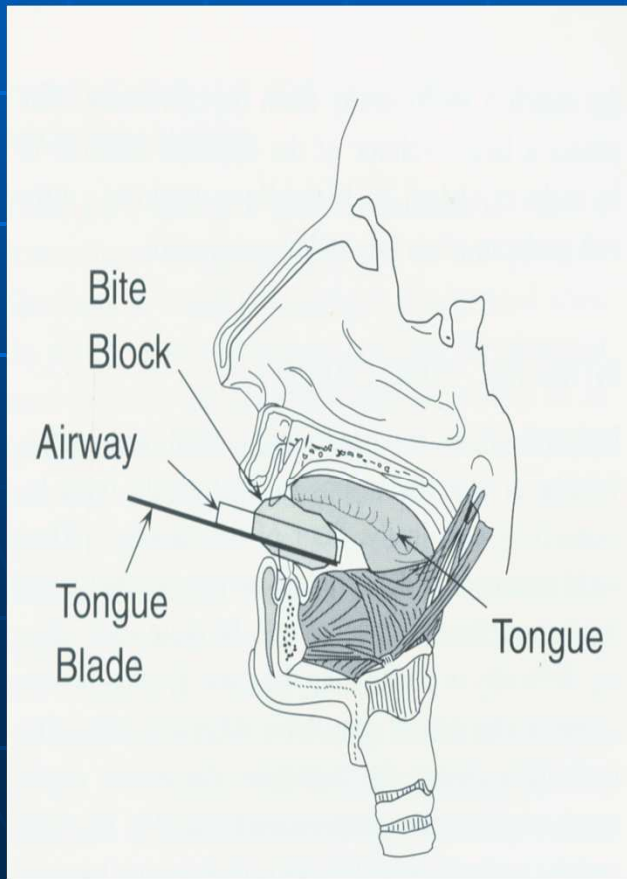
Measurement of air gap

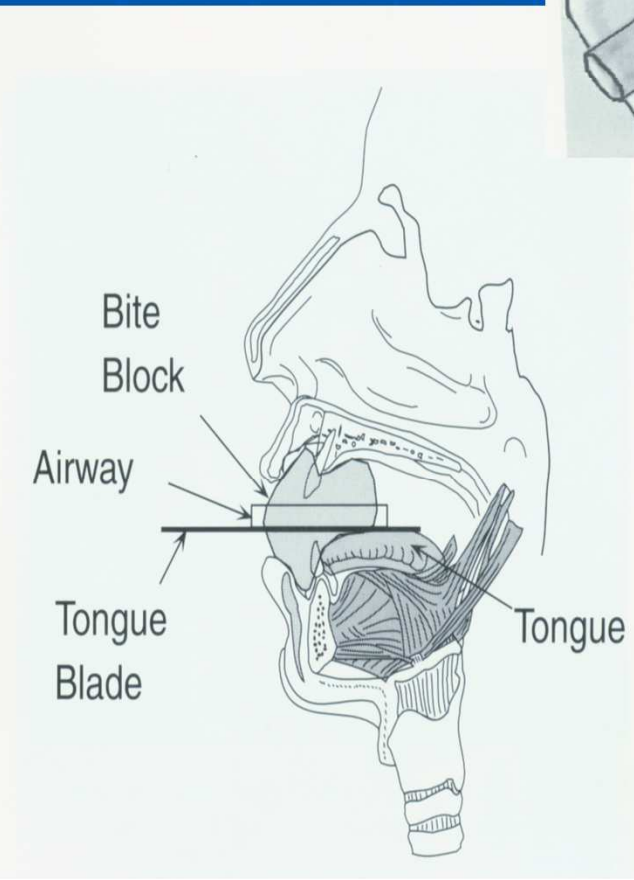
Aluminum Blocks

Final Shape

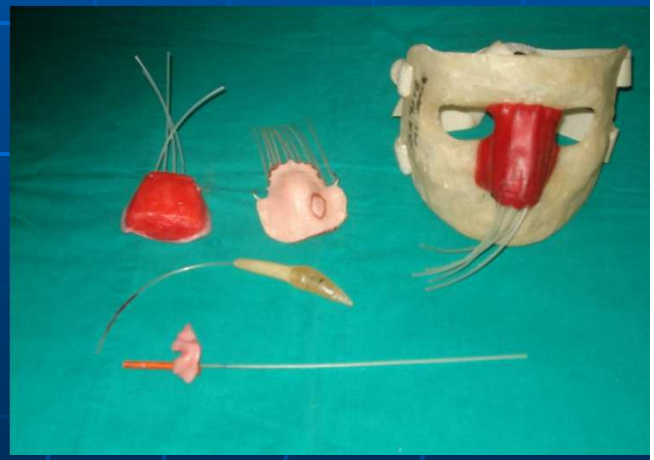
BITE BLOCK


Air way
Tongue
depressor

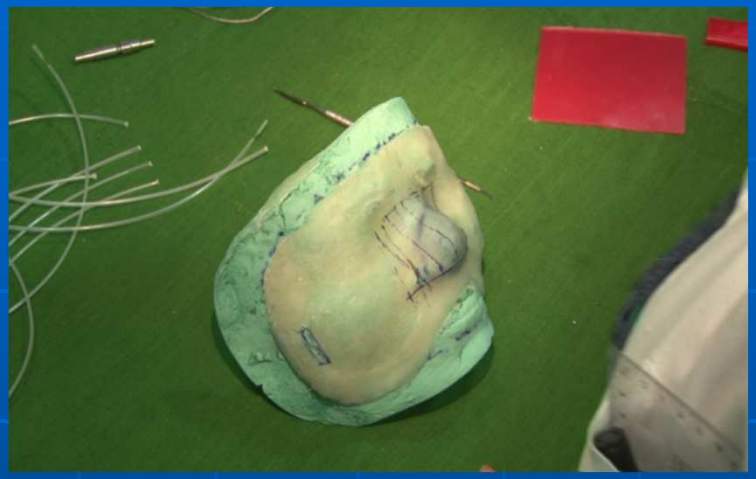

Bite
Block
Airway
Tongue
Blade
Tongue

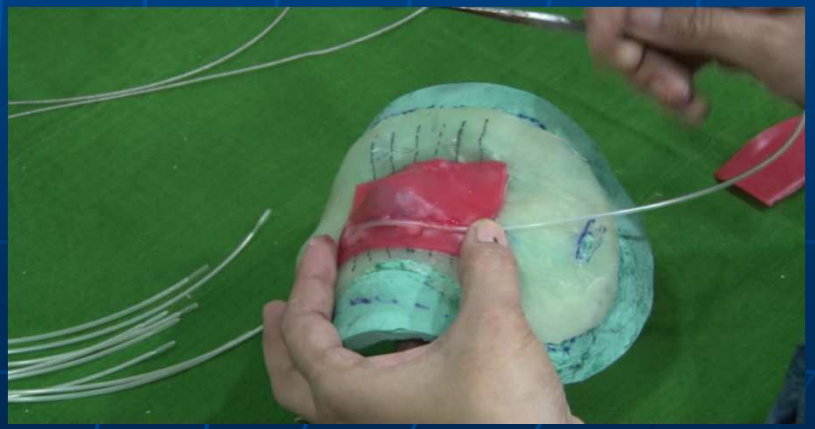

Bite
Block
Airway
Tongue
Blade
Tongue

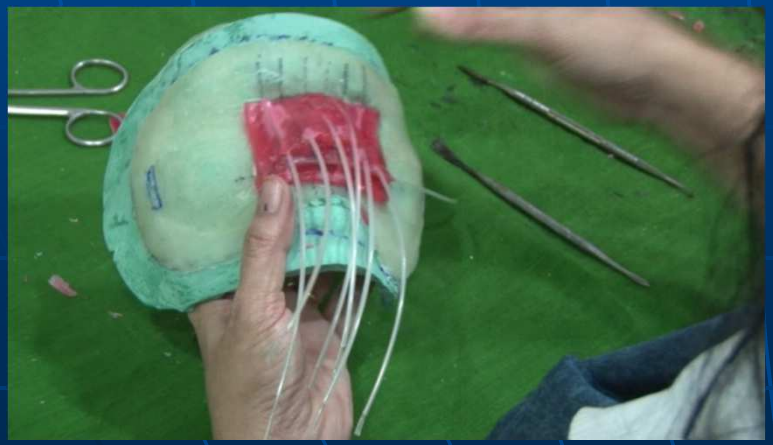
HDR Brachytherapy Surface Moulds



Making the mould



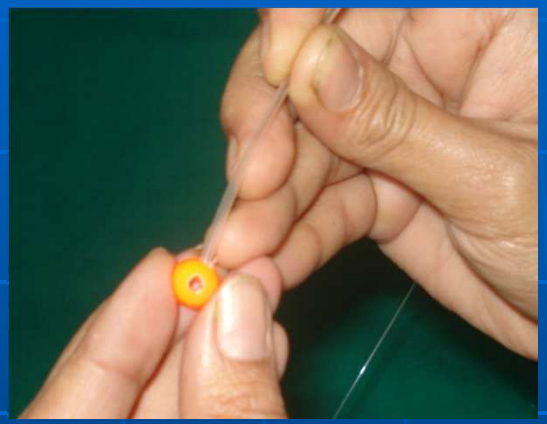


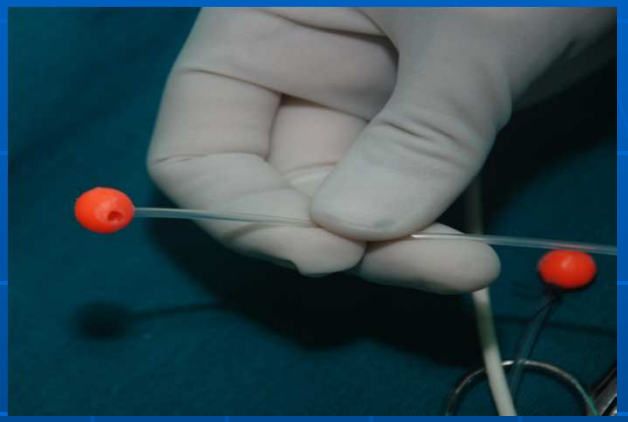


Making the mould

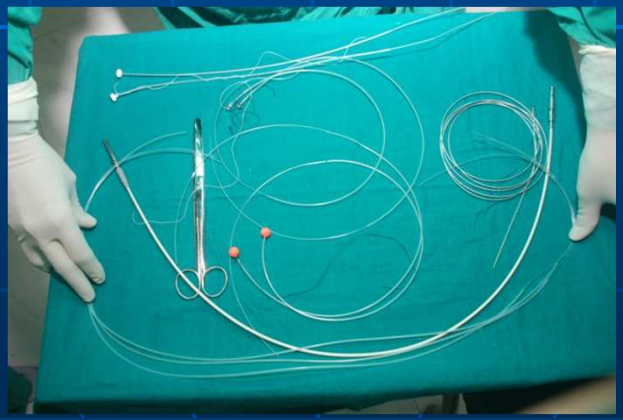
IMPLANT ACCESSORIES

CROSSING TUBES

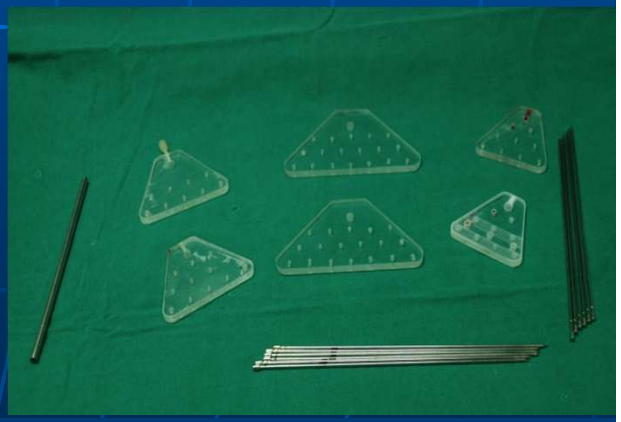




STRECHING IMPLANT TUBES

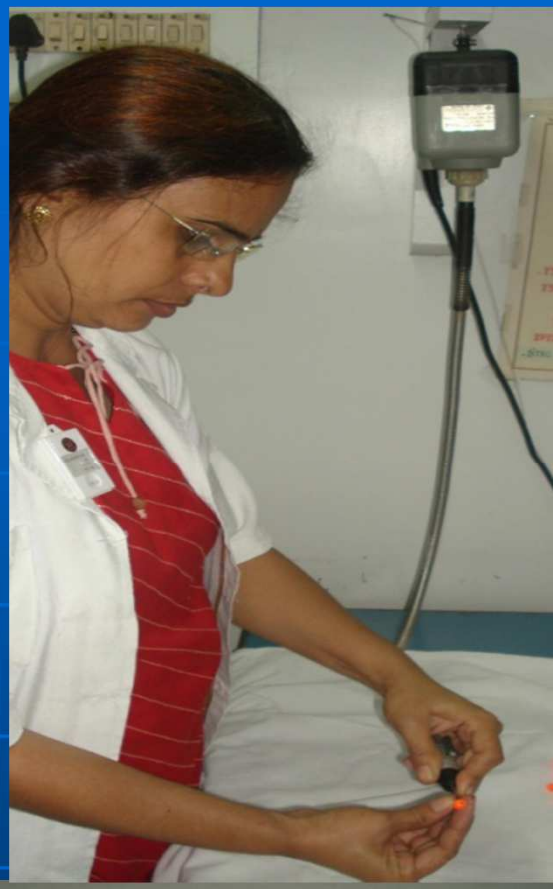


BREAST TEMPLATES



Preparation of Bead tubes

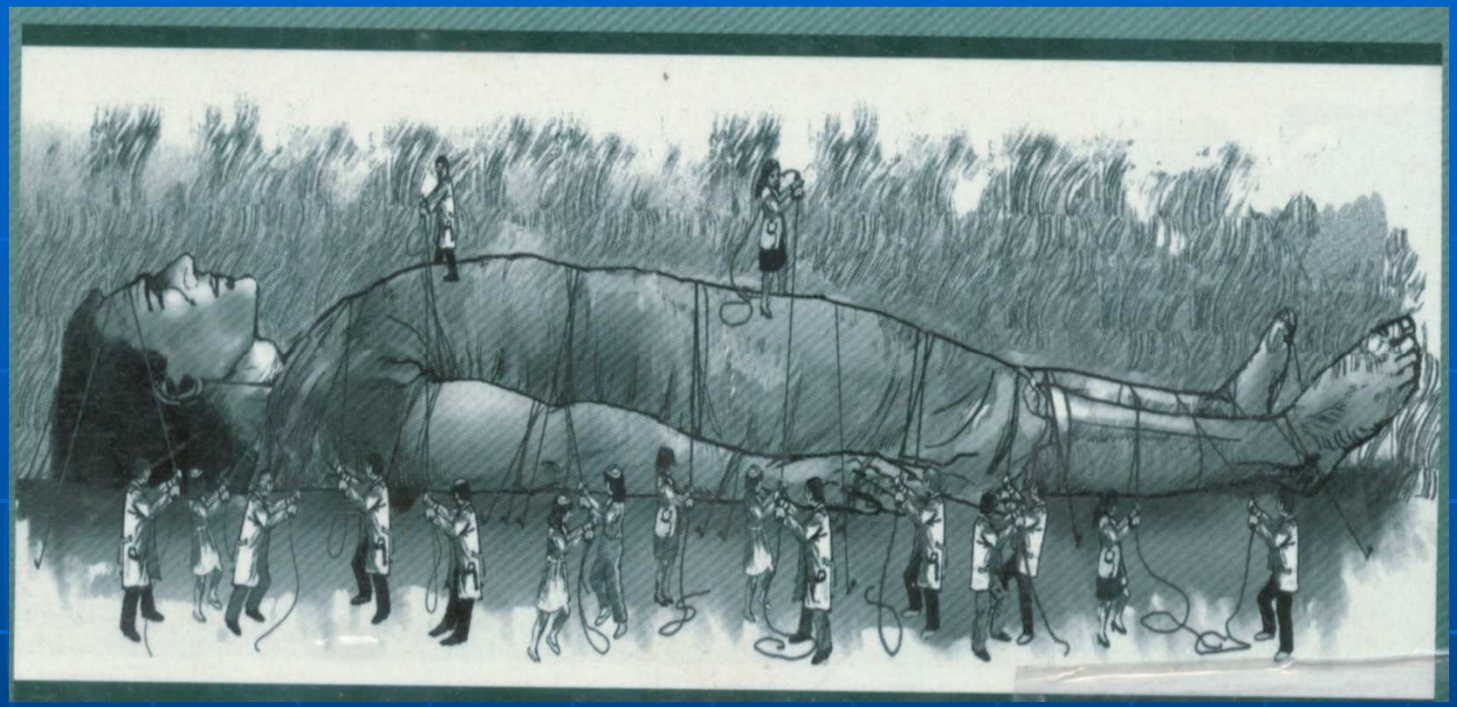
- Commercially available beads have only a single passage
- For cross beads, we need a passage perpendicular to the original passage
- A Third hole is made with a bur attached with a heavy duty dental motor



Trolley arrangement

CONCLUSION

- With increasing trend of conformal treatments the importance of immobilization has multiplied many folds
- Appropriate positioning is pre-requisite for proper immobilization
- Simple in-house devices can be designed for positioning
- Thermoplastic sheets are most common and effective method of immobilization
- It is necessary to choose carefully various H & N rests based on institutional protocols
- Considering high costs of sophisticated immobilization devices it is prudent to include detail immobilization requirement along with procurement of treatment units\
- In brachytherapy there is good scope of mould room techniques to prepare HDR moulds and other accessories for implants



IMMOBILIZATION - BE DEFINITELY BETTER THAN GULIVER'S !

Thank you