PACS Education Program

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Capstone Project

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Introduction

A member of the St. Joseph Health System of Orange, California, Covenant Health System (CHS) of Lubbock, Texas is the largest health care system in West Texas and Eastern New Mexico region. It consists of three main hospitals, Covenant Medical Center, Covenant Medical Center – Lakeside and Covenant Children's Hospital. These three facilities have a combined capacity of 1,338 beds. CHS is staffed by over 6,000 employees and has over 600 admitting physicians. CHS also has a number of affiliated and managed hospitals and clinics within the West Texas and Eastern New Mexico region. Last year, the administration of Covenant Health System decided to implement a picture archiving and communications system (PACS) at their main facilities. PACS is a computer hardware and software system that is designed to acquire, store and transmit and present digital radiographic images for interpretation and review. It is, in effect, 'filmless radiology'. All radiographic images, except mammograms, are acquired as digital data (virtual images), stored on a central server and made available on demand for viewing at computer workstations. At the workstations the images can be digitally manipulated in a number of ways in order to enhance their diagnostic value or to facilitate their viewing by the radiologist, clinician or nurse.

The hospital administration initiated the plan to acquire a PACS and chose Fuji (FUJIFILM Medical Systems, Stamford, CT) as the vendor of choice. A PACS Committee was formed and consisted of the Vice President in charge of Radiology, the two chief radiological technologists, hospital information systems (IS) personnel and four radiologists. The mission of the PACS Committee is to oversee the PACS installation, make recommendations to best serve the needs of the hospital and the clinicians and to educate the end users of the PACS. The end users consist of the radiologists, the admitting and staff physicians, the nurses, the radiology technical staff and the hospital ancillary staff who may need to use the system. The evolution (revolution?) from film based radiology to a filmless system involves a paradigm shift for everyone who uses radiographic images. For PACS to be successful, it is of paramount importance to have as smooth a transition as possible. To this end, the education of the end user is critical. I am a member of the PACS Committee and one of my duties is to be the point of contact for PACS education of physicians and nurses. Of the twenty-five radiologists on staff at CHS, only myself and one other have had experience using PACS in an actual work environment. To the best of my knowledge, only a few of

the over six hundred admitting physicians on staff have had personal experience with PACS and I would assume the same is true of the nursing staff.

The hospital ran an article about PACS in the recent issue of the Medical Staff Newsletter. This publication is distributed to the admitting physicians of the hospital. The hospital also ran a special PACS edition of the Covenant Connection, the newsletter that is distributed to the employees of the hospital. These articles announced the hospital's decision to implement PACS this fall and described the advantages of PACS over hard copy film radiology. The articles were primarily public relations type news pieces, important for making the physicians and staff aware of the hospital's decision to implement PACS. They do not go into detail about how PACS will function, the changes that we will have to make in how we view radiographic images, and they don't address questions that the end users might have about PACS. In meetings with clinicians I learned that there is a wide range of opinion about the transition to PACS. Some groups (e.g., the emergency room physicians) are very enthusiastic about the change. Most of them are computer literate and they look forward to the efficiencies that PACS promises, studies performed more rapidly, more rapid interpretation of radiographic images, more rapid reporting of radiographic findings, electronic communication with the radiologists via PACS, all resulting in faster diagnosis and treatment of patients in the emergency room. On the other hand, some groups that I spoke with are more divided in their opinions. The orthopaedic surgeons had views of PACS that ranged from highly enthusiastic to hostile. Many of them admitted to being computer illiterate and they were very resistant to having to learn how to operate a workstation in order to view their 'films'. The hospital Vice President in charge of radiology plans to meet one on one with physicians in their offices to explain PACS, but this will be a time consuming and inefficient method of educating the clinicians. It also doesn't address the needs of the other end users such as the nursing staff. Clearly, an educational module is needed that can be used to address large audiences of end users. To this end I have undertaken the task of developing a PACS education module using PowerPoint. I chose PowerPoint because it is a well recognized application for education, it is transportable, it is compatible with various operating systems (it is cross-platform), it permits modification of the content of the presentation with relative ease as new information becomes available, and can be tailored to meet the needs of various audiences. My presentation is designed to be presented in formal or semi-formal settings. In it, I will review the history of PACS, its advantages and disadvantages and the necessity of changing the way we work with radiographic images. I will

address the questions and issues of members of the audience and will provide them with a method (phone number and email address) by which they can have any other questions answered.

In the two weeks prior to PACS implementation Fuji will be conducting small group training sessions in the use of the PACS workstation for the benefit of the end users. My educational program will be presented to larger groups of end users prior to this and will bridge the gap between the public relations announcements about PACS and the small group training sessions.

The Presentation

The PowerPoint presentation that I have produced consists of six modules: (1) an introduction, (2) a discussion of the history of PACS, (3) a clinician module which includes a discussion of the advantages and disadvantages of PACS and the functions of the PACS workstation, (4) a workstation module that describes the functions of the workstation, (5) a radiological technologist module that discusses PACS for the point of view of the technologist, and (6) a technical module that discusses the technical considerations of PACS. There is some overlap in several of the discussions and because of this some slides are used in more than one module. The modules are designed to be used as stand alone presentations depending on the needs of the target audience. Each module, except the short introduction module, includes my name and email address as the final slide and audience members will be encouraged to contact me with if they have any questions or suggestions about the material.

The clinician module and the workstation module include an introduction to the workstation functions. These functions include magnification, zooming, changing contrast, rotating or flipping the image, annotating the image and sending messages electronically. They also discuss the way the user can define his or her preference for the way in which the images are oriented on the screen (hanging preferences). This will segue well into the vendor's small group training session where the workstation functions will be demonstrated and the end users will have the opportunity to call up and manipulate images on actual workstations.

Lessons learned

PACS is a hardware and software package that is being purchased by the hospital. It involves making and approving the decision at the highest level of hospital administration. It involves cost / benefit analysis, vendor selection, and massive changes in the infrastructure of the

hospital. This includes extensive site preparation, including making sure that the equipment in the department (fluoroscopic units, plain film units, ultrasound, computerized tomography (CT) units and MRI units) are capable of handling digital imaging and interfacing with the PACS server and workstations. Equipment that is not able to perform these tasks must be upgraded or replaced by suitable equipment. High bandwidth cables must be run throughout the facility in order to effect image transmission from the PACS server to the remote workstations. A large amount of computer hardware must be installed. For these tasks hospital employee manpower and budgets must be brought to bear. Therefore, a large part of the transition to PACS is controlled by the hospital.

Being primarily a clinical tool for image acquisition, storage, transmission, interpretation and review, a large part of the daily use of PACS is clinical. The radiologists, who will be using the PACS throughout their workday, must be able to advise the hospital on details that affect them. They must also communicate with the clinicians and other end users to get their input and to help the hospital to address their needs. The input of the end users is critical to the acceptance and success of PACS. The conversion to PACS must be a combined effort of both the hospital administration and the end users. Neither group alone can effect the change, and the needs of both groups must be acknowledged and addressed.

It is important to consider the timing of the announcement regarding the transition to PACS and the timing of the educational programs for the end users. If the transition is announced and the training takes place too early, say six months to one year before the transition is scheduled to occur, there may be a loss of interest among the end users and the training may be forgotten before the installation of the system. If the announcement is made too late, say one to two months before the installation, the end users may feel that they were left out of the decision making process and regard the implementation with hostility. It would seem that a two to three month lead time would be proper for the announcement of the change. This allows enough time for questions to be asked and issues to be addressed, and leaves enough time for minor changes to be made if necessary. The general educational programs can begin within a week or two of the announcement. The small group training sessions should be left till just before the ‘go live’ date so that the details of how the workstations function will still be fresh in the minds of the end users.

There is a lot of material to consider when discussing PACS. Different audiences have different needs. Rather than develop one presentation which would be too superficial and not address the specific needs of my anticipated target audiences, I came to the realization that the best

way to prepare this material was to create several presentations that can be used individually or combined, as needed, depending on the needs of the target audience.

Capstone Project
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PACS

Introduction

Picture
Archiving and
Communications
System

PACS

Digital image acquisition, storage and transmission

PACS differs
from
film based radiography

PACS affects

- Radiologists
- Radiological technologists
- Clinicians
- Nurses
- Hospital administrators
- Film filing personnel

The future of radiological imaging is

PACS

And the future is

NOW

PACS
Part 1
History

In the beginning …

there were direct digital modalities:

CT, Ultrasound, Nuclear,
Magnetic Resonance

Which introduced people to the flexibility inherent in digital imaging - rapid access to images, manipulation of image contrast, etc.

Problems of early digital imaging:

Multiple vendors +
Proprietary systems
= Incompatibility

Enter DICOM

Digital Imaging and Communications in Medicine

DICOM is based on the American College of Radiology (ACR) and National Electrical Manufacturers Association (NEMA) standard

ACR-NEMA standard

- 1983 Established
- 1985 ACR-NEMA standard v1.0
- 1988 v2.0
- 1993 DICOM v3.0
- Continuous evolution

Ref 11

DICOM standardized communications protocols for image and image identification data so that equipment items from different vendors could communicate with each other.
It is a non-proprietary, open architecture standard.

Open architecture - RADICAL CONCEPT!

Different pieces of equipment could communicate with each other, and could share the same patient demographic data from the hospital information system (HIS) or radiology information system (RIS),

- IF -

all the pieces of equipment were DICOM compatible.

What catalyzed PACS?

- Increased number of studies ordered
- Increased number of images per study
- Increased use of personal computers

Advantages of PACS

- Images can be manipulated to enhance diagnostic value
- No lost films
- No loss of resolution when images are copied

More advantages …

- Simultaneous viewing
- Consultation at a distance
- Decreased repeat rate

Still more advantages …

- Leveled workload
- Ability to annotate images
- Instant messaging

Even still more advantages …

- Images can be stored on CD or DVD for the patient or physician
- Ease of conversion of images to multimedia teaching files

PACS and the internet

Images can be transmitted to personal computers via the internet (using a secure connection) and can be accessed by physicians at their offices or homes

Technical limitations of early PACS

- Computer equipment was expensive
- Computer memory was limited
- Storage memory was expensive and limited

More limitations …

- Images files are large
- Transmission times were SLOW

And still more limitations …

- High resolution monitors were expensive
- Limited image manipulation functions
- Not user friendly

Administrative limitations

- No positive financial return for the institution
- What if we are the ‘only show in town’?
- Fear of obsolescence

Enter …

- Less expensive computers and monitors
- Less expensive memory
- More user friendly software (GUI)
- More standardized controls (icons)

PACS becomes more feasible

The first institutions to install PACS were governmental institutions (military and Veterans Administration facilities)

Reliable source of funding

Relatively stable patient population

As hardware costs decreased and the advantages of PACS were realized and reported in the literature, PACS became a more realistic solution to the problem of increasing demand for radiological services.

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PACS and the clinician

(What is means to you.)

Advantages of PACS

- Images can be manipulated to enhance diagnostic value
- No lost films
- No loss of resolution when images are copied

- Simultaneous viewing
- Consultation at a distance
- Decreased repeat rate
- Leveled workload
- Ability to annotate images
- Instant messaging

- Images can be stored on CD or DVD and given to the patient or physician
- Ease of conversion of images to multimedia teaching files
- More rapid delivery of reports (Ref 5)

- Reports are included with the images
- Fewer interruptions of clinicians - 91% of physicians reported that they did not want to receive phone calls for routine results (Ref 7)

- Referring clinicians are able to review their images at times that are most convenient for them from within or from outside the facility via secure web based access

Ref 7

Web access to images and reports

- Secure socket layer (SSL) guarantees integrity of data and confidentiality between client and server
- 128 bit encryption
- Ensures that the user has access only to data that he/she actually needs

Ref 9

- Reduced number of unreported cases after PACS installation (Ref 5)
- Time saved by clinicians after PACS installation ~ 30 minutes per day (Ref 5)

- 70% decrease in time for images to be available with PACS vs conventional film imaging (Ref 12)

Referring physicians prefer PACS over film with 91% reporting improved productivity with PACS

Ref 7

Workstations

- High resolution monitors (‘standard’ is 2 megapixels, but can be up to 4 megapixels)
- Increased resolution --> increased cost
- 1, 2, 4 or 8 monitors?

Workstation functions

- Change contrast
- Invert gray scale
- Flip
- Rotate
- Magnify

Workstation functions cont'd …

- Pan
- Zoom
- Measure
  - Linear distance, area, angle, density

Workstation functions cont'd …

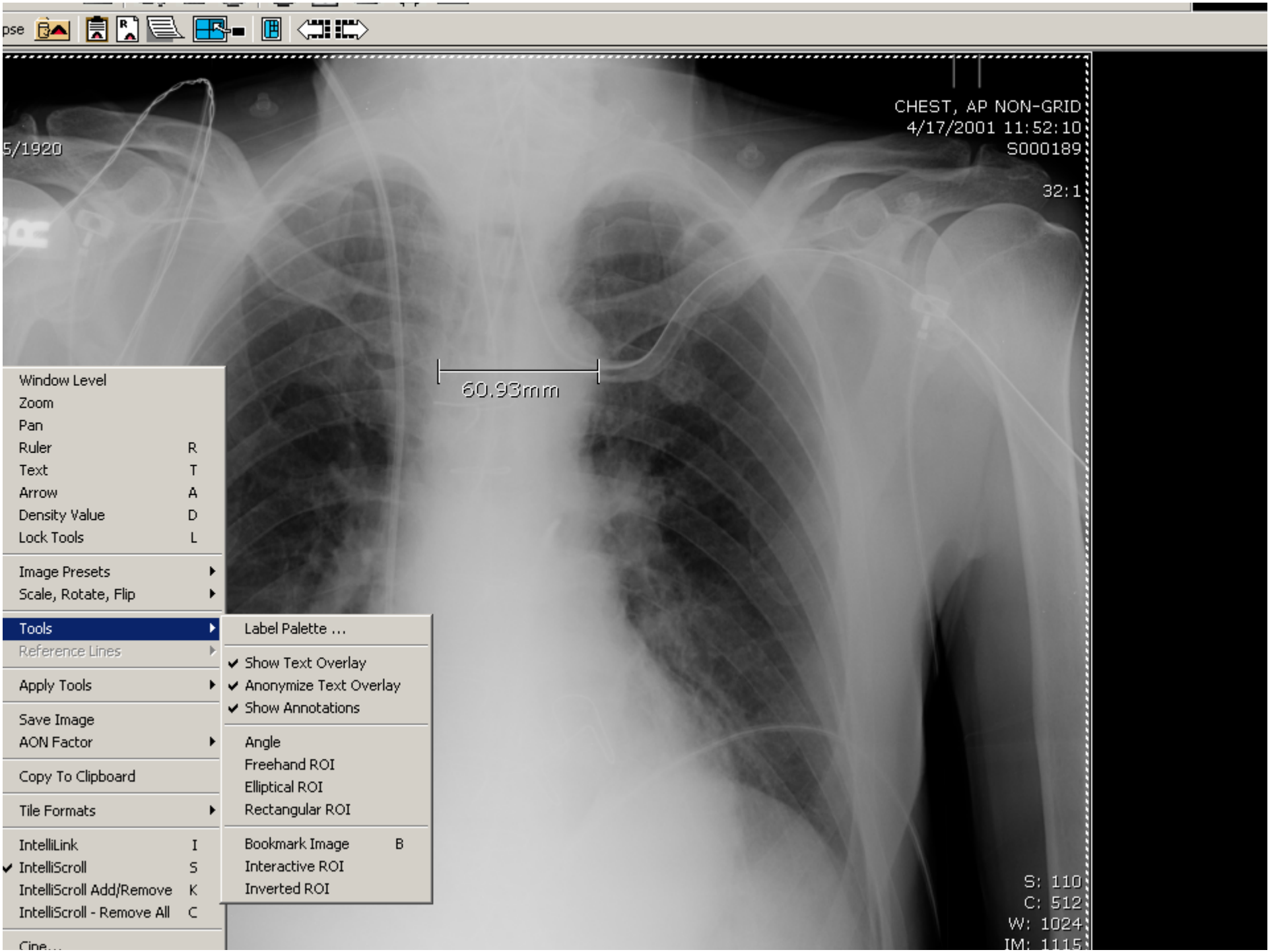
- Set individual preferences
- Choice of hanging protocols
- Automatic retrieval of comparison images

PACS screen images
provided courtesy of

FUJIFILM Medical Systems
USA, Inc.

With deepest appreciation to
Betty Assadullahi
FUJIFILM Medical Systems
USA, Inc.

Chest image with tool bar and pull down menus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Ruler R
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Density Value D
Lock Tools L
Image Presets
Scale, Rotate, Flip
Tools
Reference Lines
Apply Tools
Save Image
AON Factor
Copy To Clipboard
Tile Formats
IntelliLink I
IntelliScroll S
IntelliScroll Add/Remove K
IntelliScroll - Remove All C
Label Palette ...
Show Text Overlay
Anonymize Text Overlay
Show Annotations
Angle
Freehand ROI
Elliptical ROI
Rectangular ROI
Bookmark Image B
Interactive ROI
Inverted ROI

Chest image, uncompressed

Montana, Joe
9000009

11/5/1968
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CHEST
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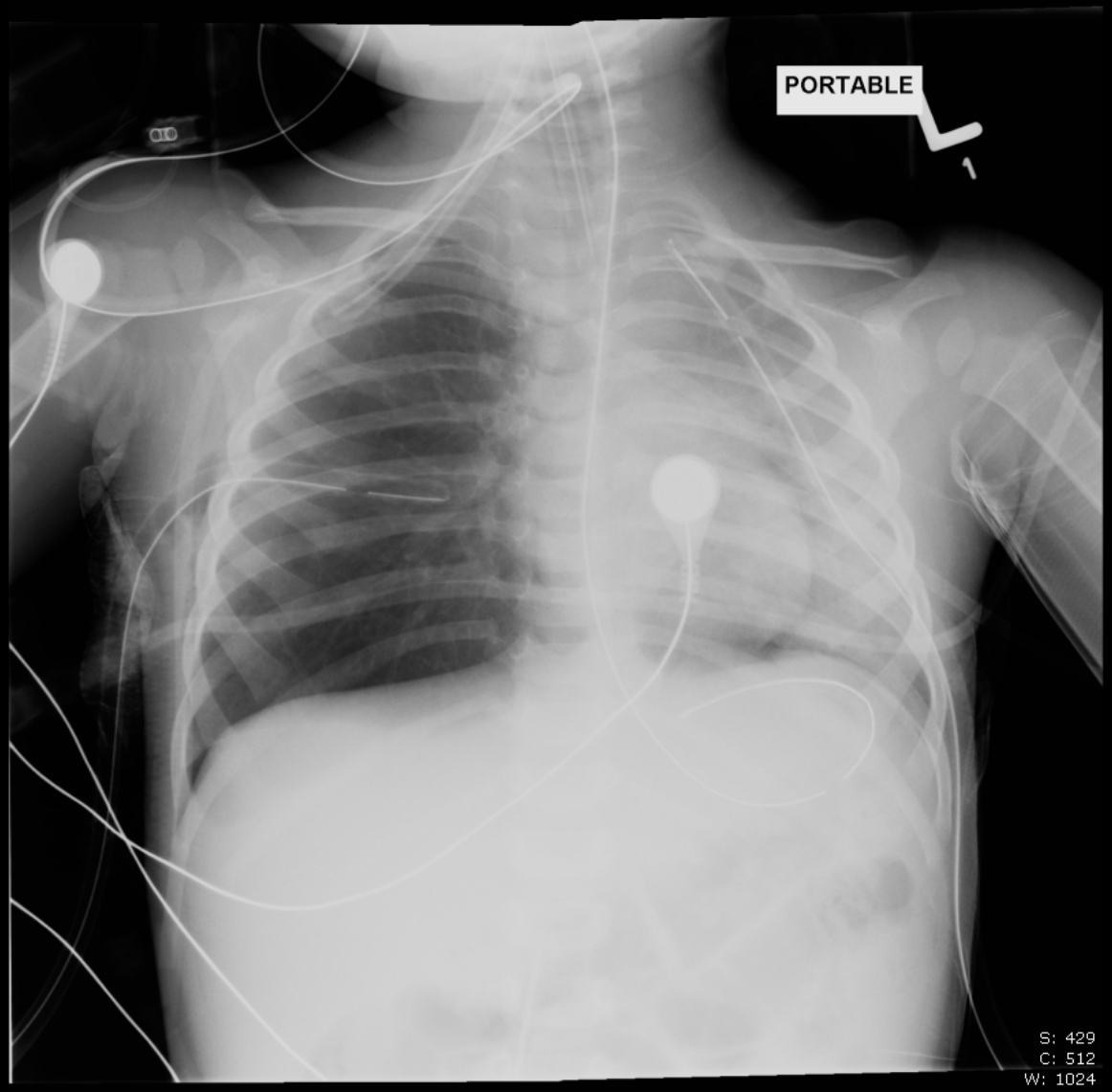
G000026

Uncompressed CR Chest



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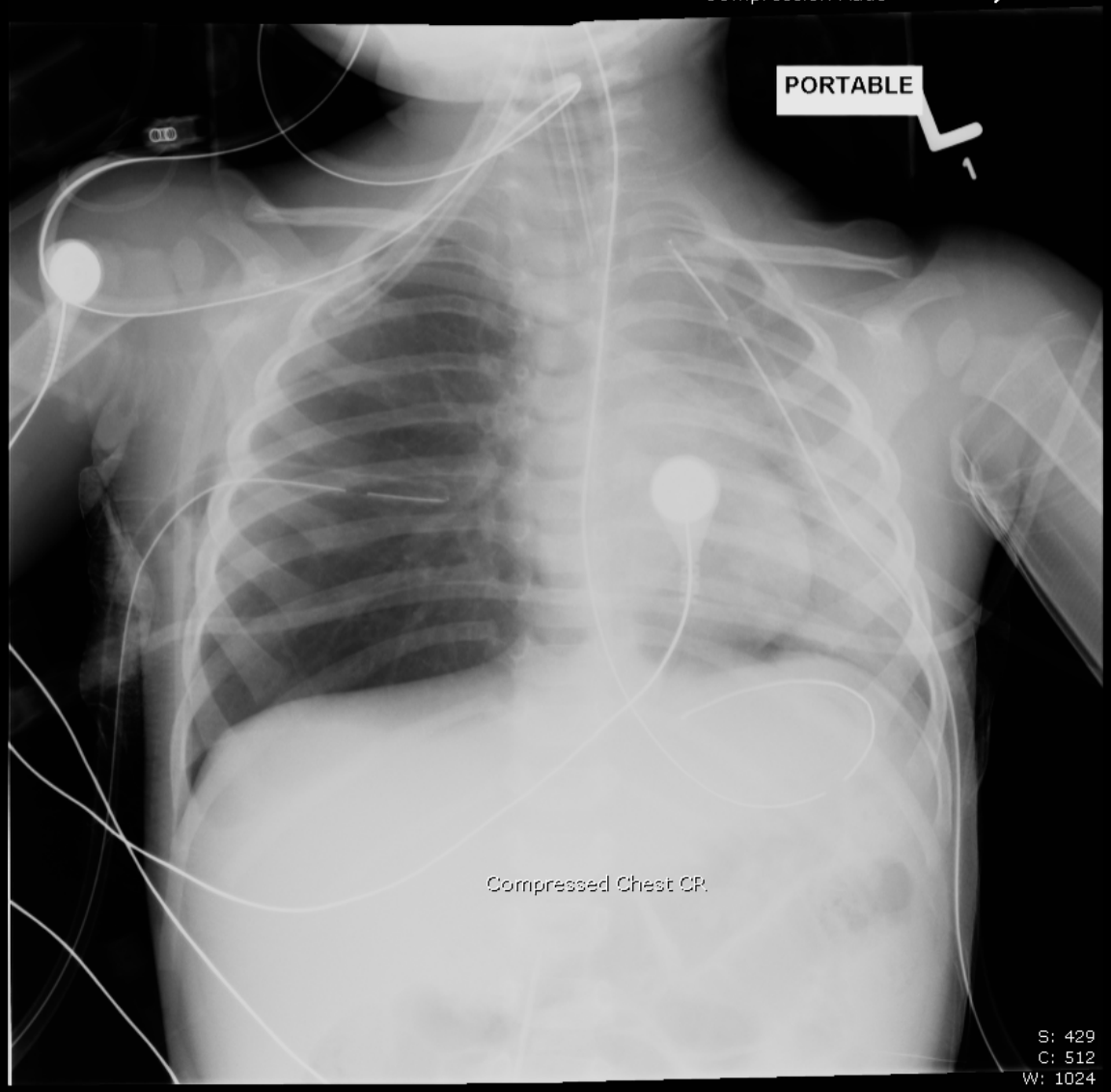
Chest image, compressed 32:1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Compressed Chest CR
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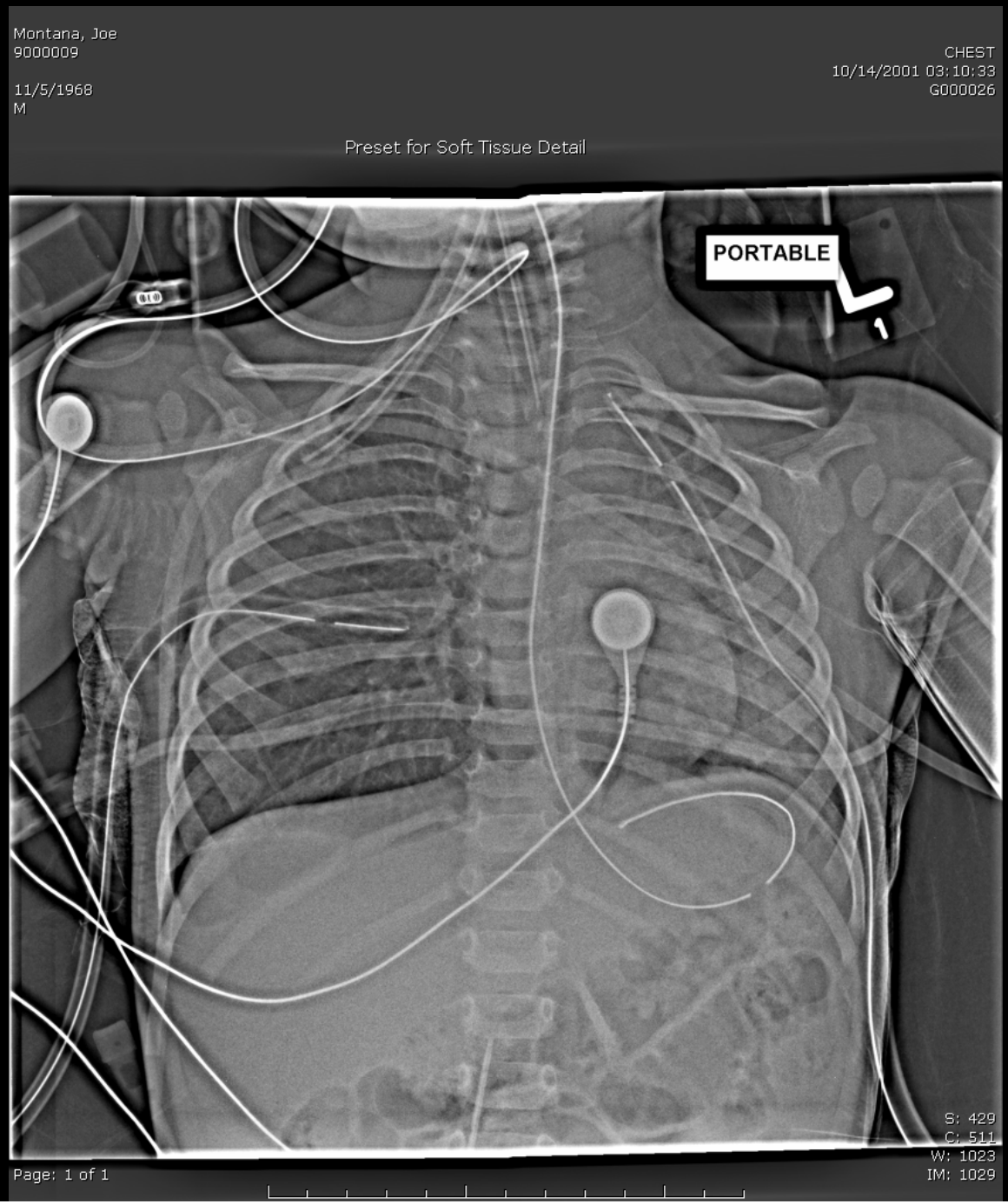
C: 512
W: 1024
IM: 1029
Page: 1 of 1

Chest image, soft tissue detail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Page: 1 of 1

Chest image, line placement

Montana, Joe
9000009

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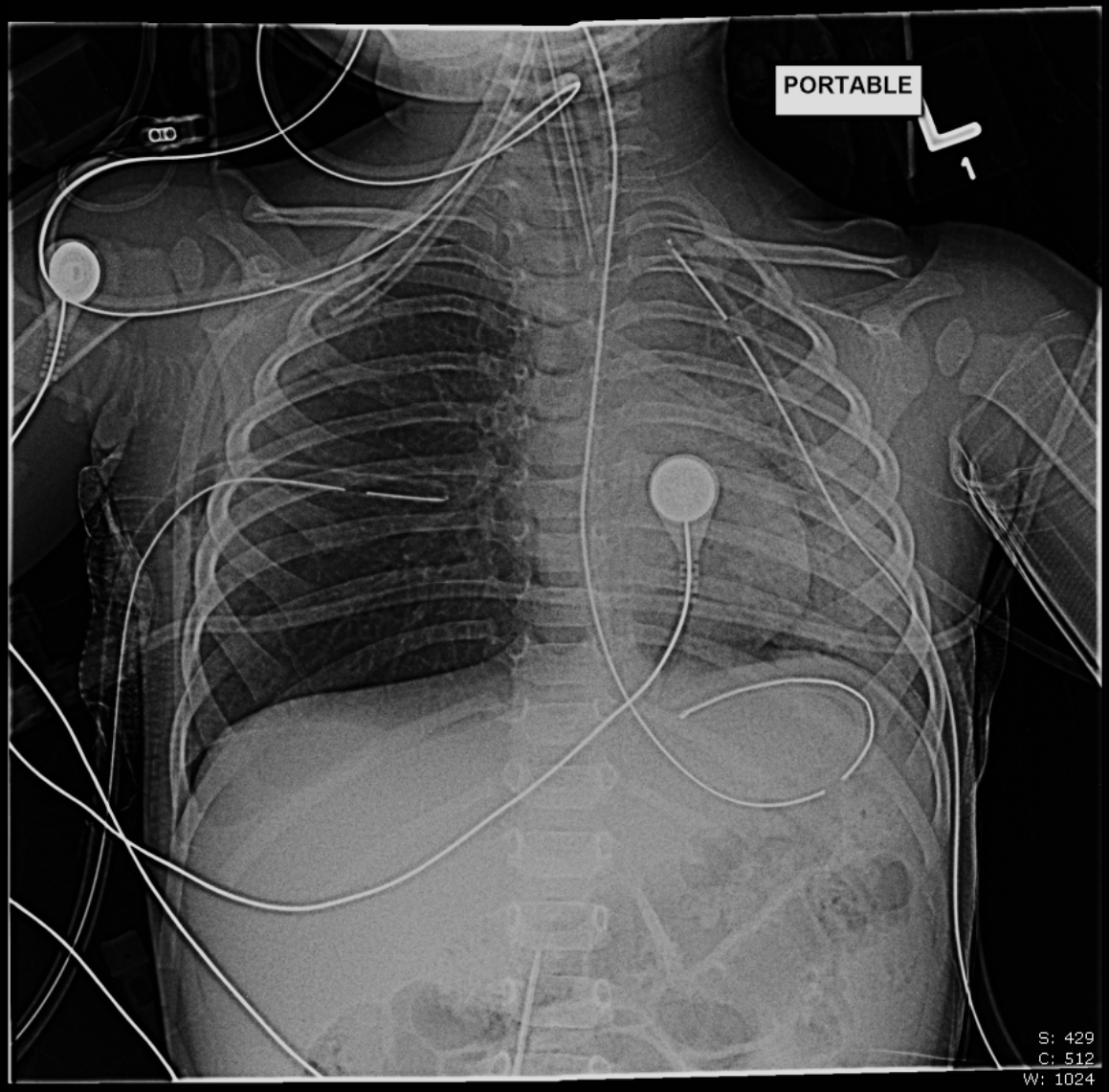
G000026

Preset for Chest Line Placement



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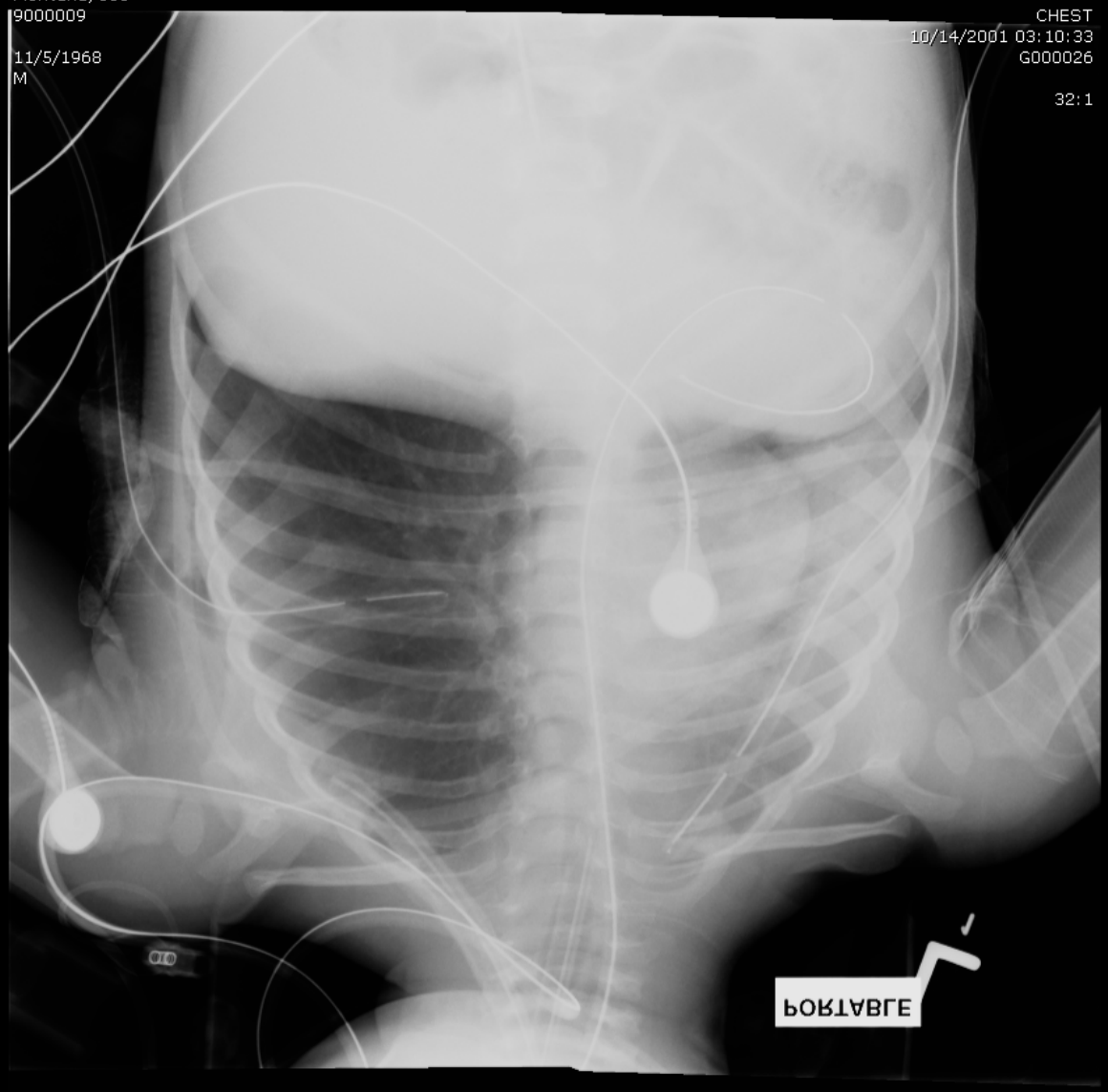
Chest image, examples of ‘flip’ function



Flipped Image

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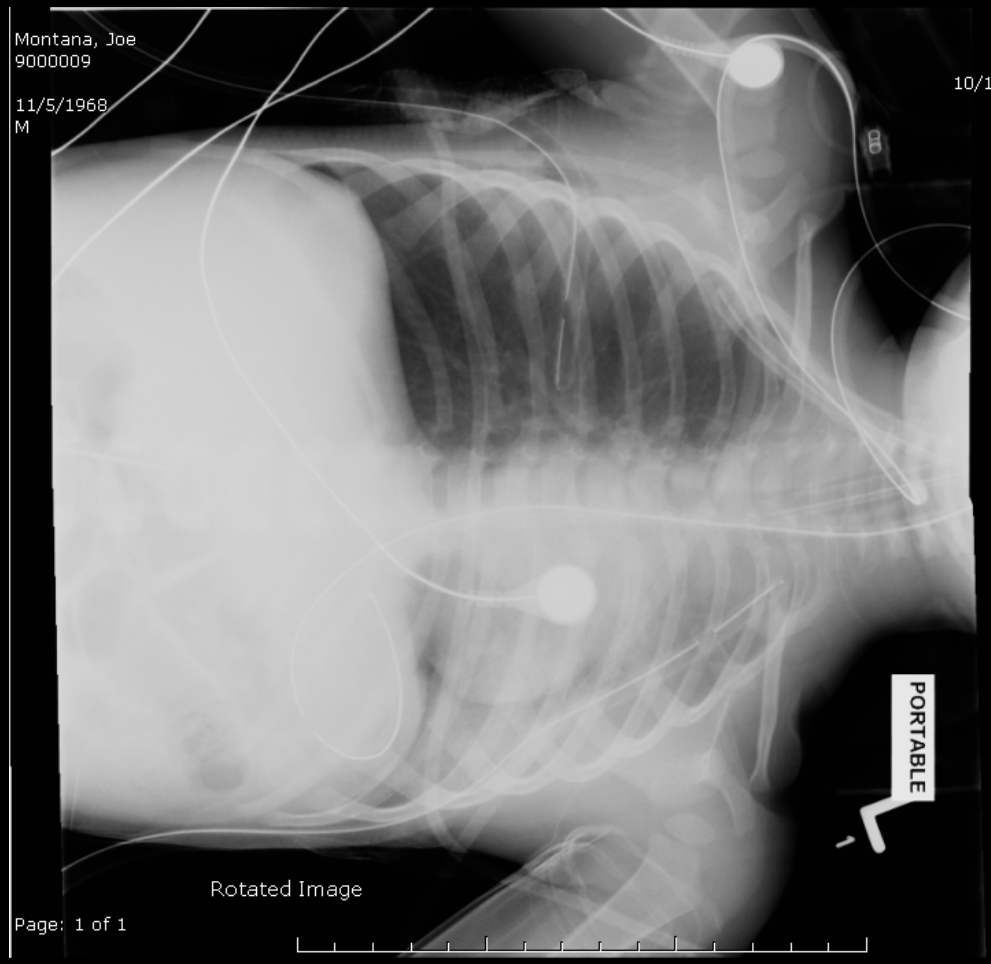
Page: 1 of 1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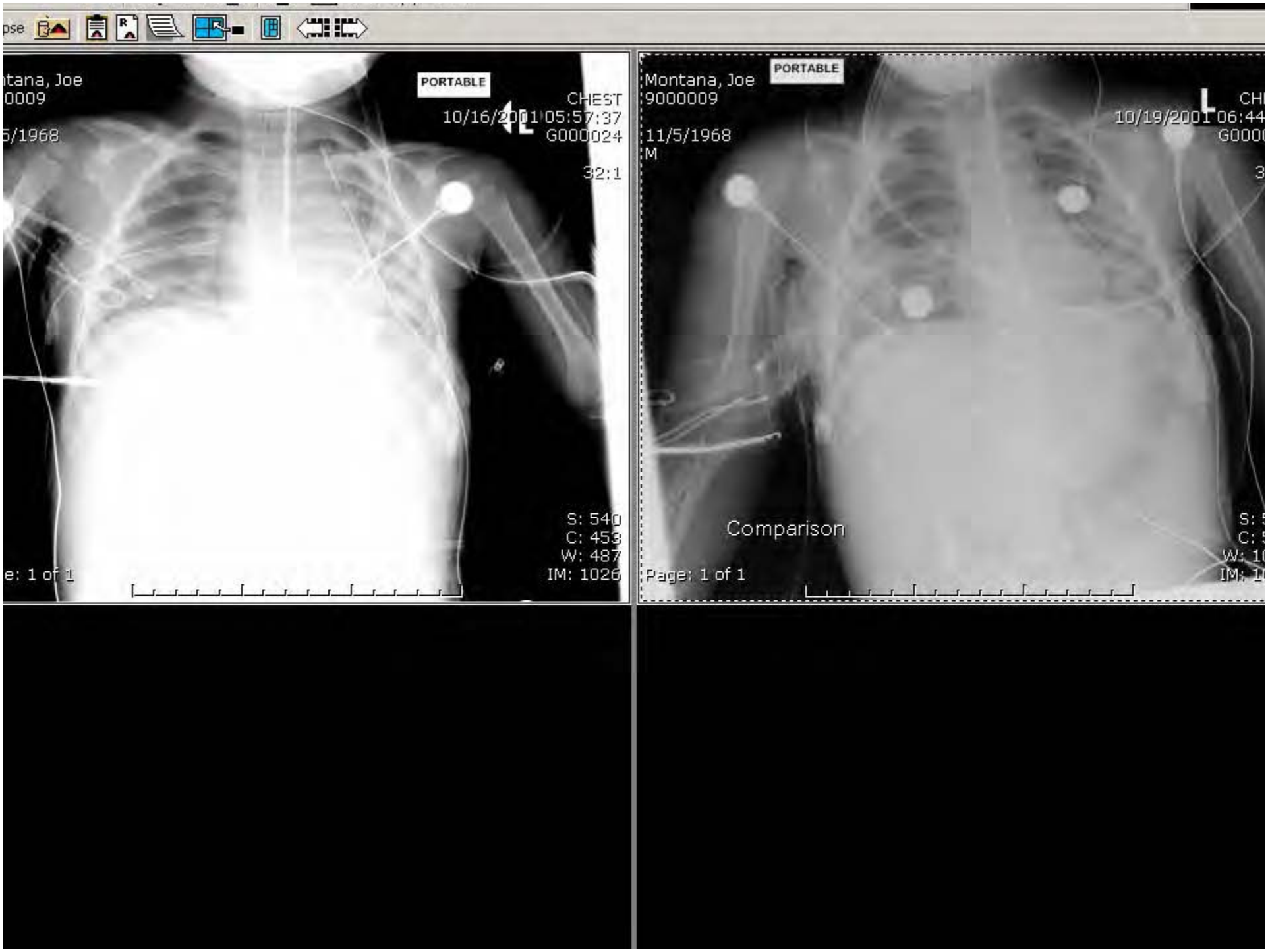
Chest images, side by side comparison hanging protocol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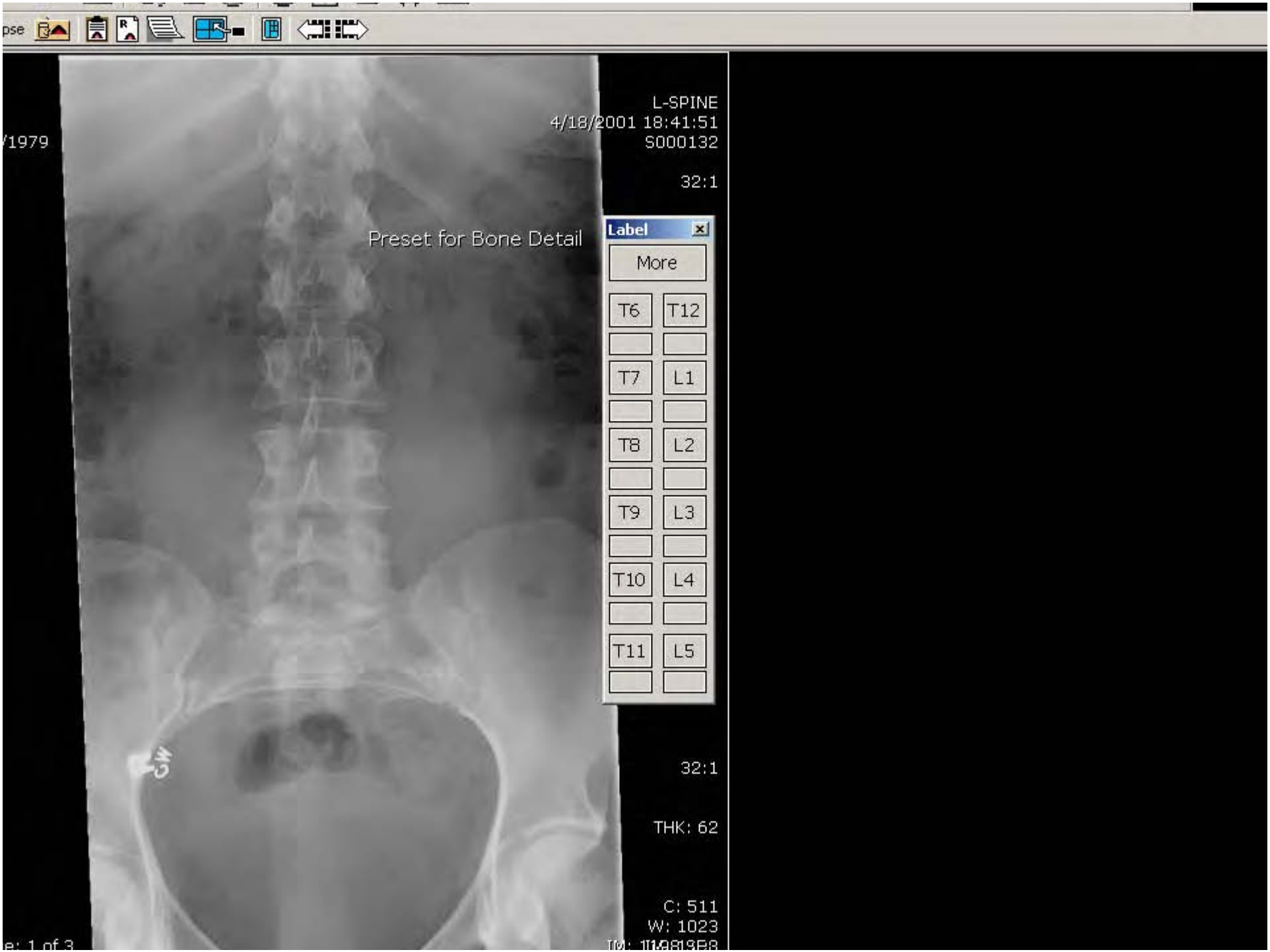
Comparison
Page: 1 of 1

L-spine, bone detail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THK: 62
C: 511
W: 1023

Foot, showing magnification function and cm scale


FOOT
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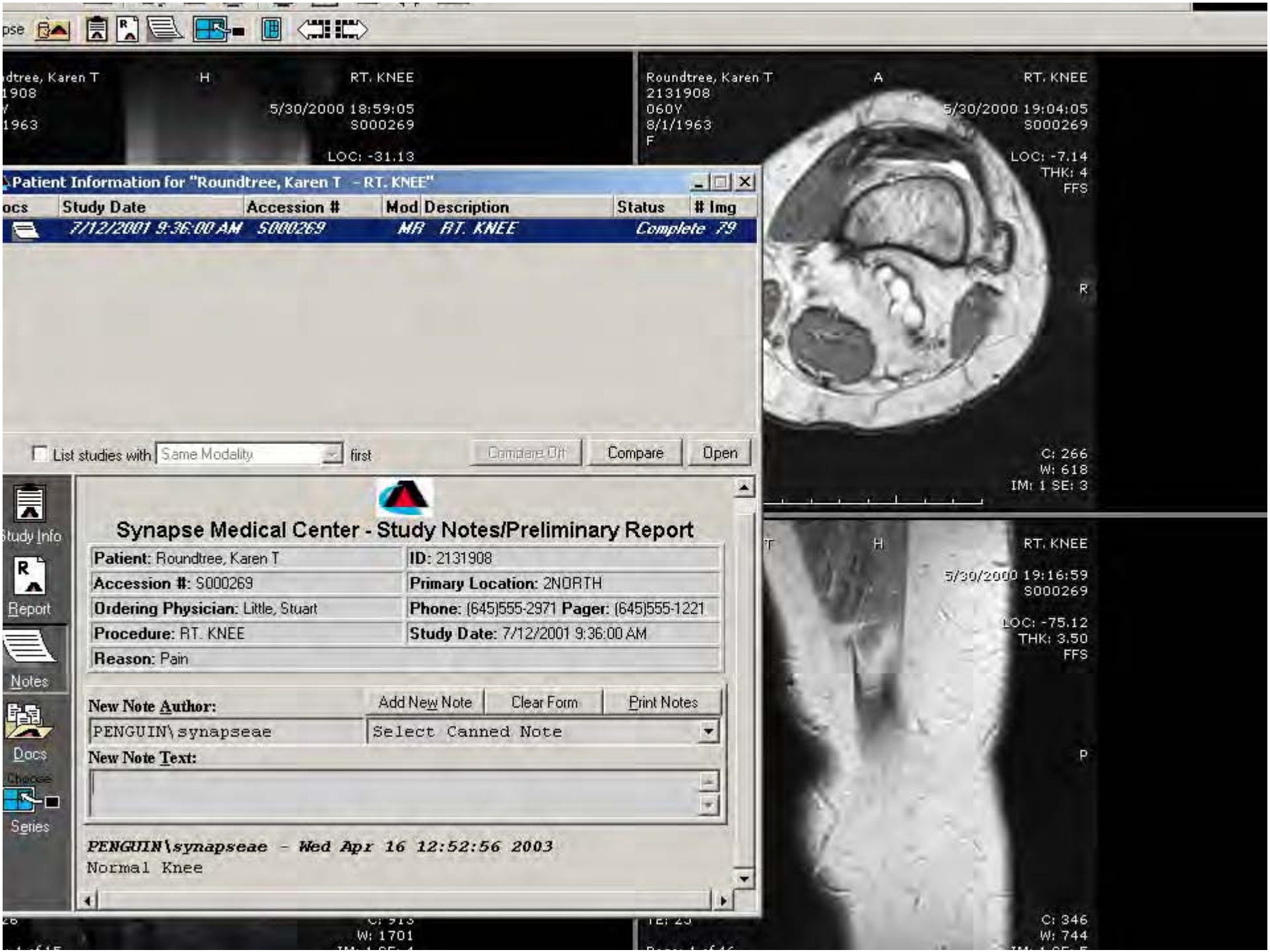
W: 1024

MRI image, showing patient information and ‘note’ function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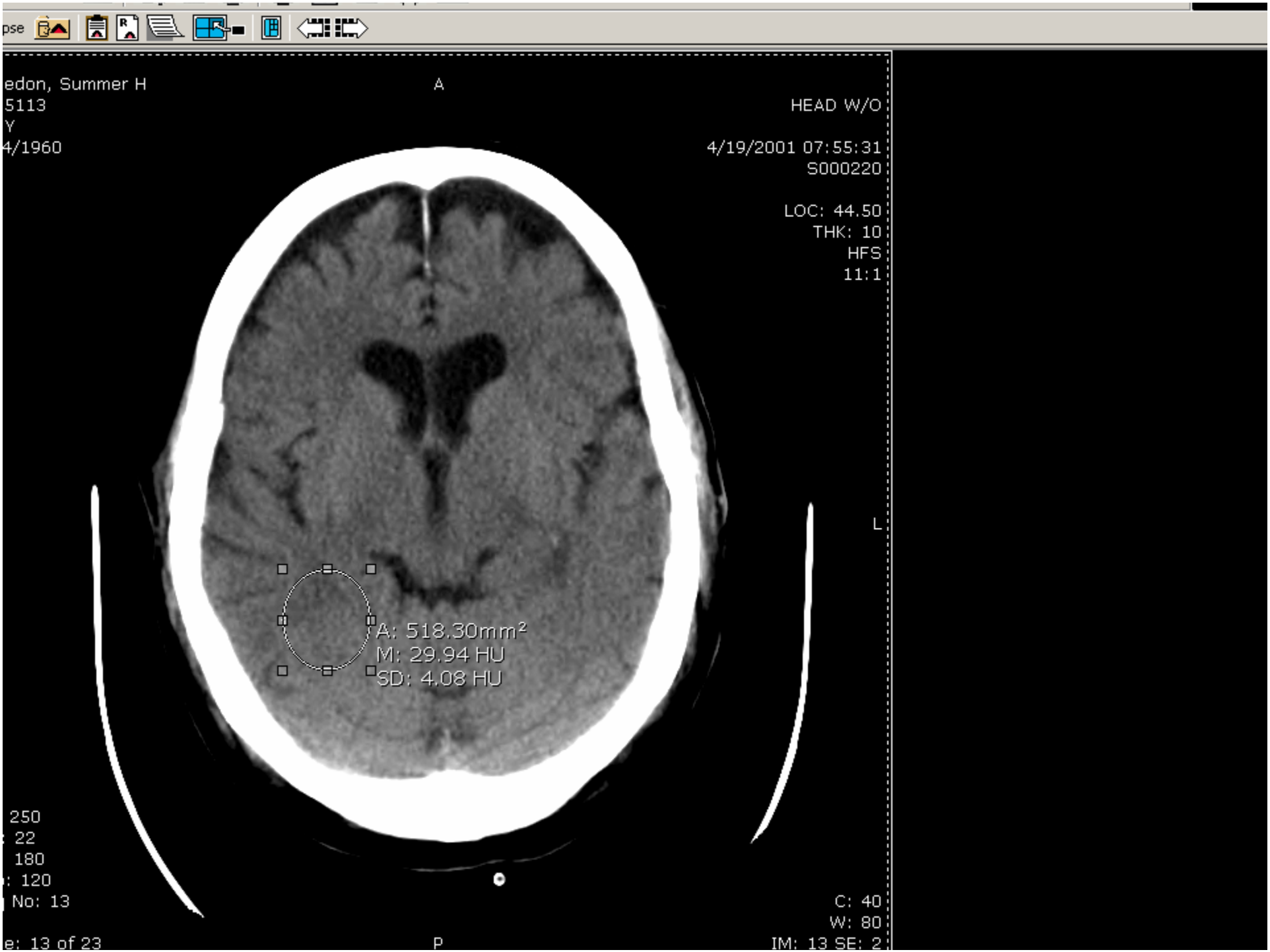
A
RT. KNEE
5/30/2000 19:04:05
S000269
LOC: -7.14
THK: 4
FFS
R
C: 266
W: 618
IM: 1 SE: 3
Patient Information for "Roundtree, Karen T - RT. KNEE"
ocs
Study Date
Accession #
Mod
Description
Status
Img
7/12/2001 9:36:00 AM
S000269
MR
RT. KNEE
Complete
79
List studies with
Same Modality
first
Compare Off
Compare
Open
Study Info
Report
Notes
Docs
Choose Series
Synapse Medical Center - Study Notes/Preliminary Report
Patient: Roundtree, Karen T
ID: 2131908
Accession #: S000269
Primary Location: 2NORTH
Ordering Physician: Little, Stuart
Phone: (645)555-2971 Pager: (645)555-1221
Procedure: RT. KNEE
Study Date: 7/12/2001 9:36:00 AM
Reason: Pain
New Note Author:
Add New Note
Clear Form
Print Notes
PENGUIN\synapseae
Select Canned Note
New Note Text:
PENGUIN\synapseae - Wed Apr 16 12:52:56 2003
Normal Knee
T
H
RT. KNEE
5/30/2000 19:16:59
S000269
LOC: -75.12
THK: 3.50
FFS
P
C: 346
W: 744
W: 1701

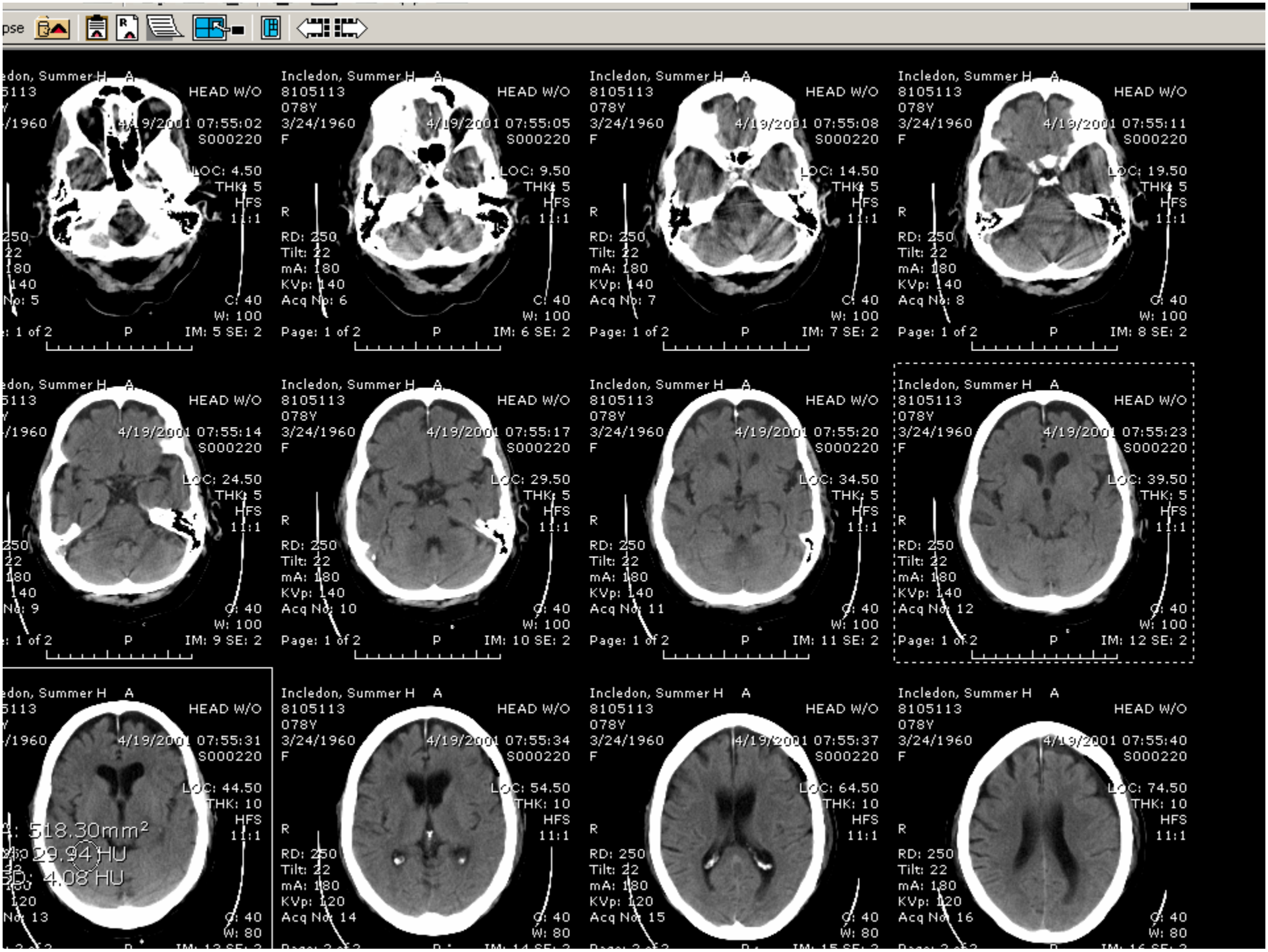
Knee MRI, showing multiple sequence hanging protocol and plane of interest function


dtree, Karen T
1908
1963
H
RT. KNEE
5/30/2000 18:59:05
S000269
LOC: -31.13
THK: 10
FFS
P
E QUAD
20
10
4
C: 388
W: 806
: 1 of 3
IM: 1 SE: 2
Roundtree, Karen T
2131908
060Y
8/1/1963
F
A
RT. KNEE
5/30/2000 19:04:05
S000269
LOC: -7.14
THK: 4
FFS
L
R
KNEE QUAD
FE
FA: 35
TR: 660
TE: 15
C: 266
W: 618
Page: 1 of 15
45
25
1
M: 1 SE: 3
dtree, Karen T
1908
1963
H
RT. KNEE
5/30/2000 19:08:21
S000269
LOC: -36.28
THK: 4
FFS
L
E QUAD
90
2000
26
C: 913
W: 1701
1
25
45
Roundtree, Karen T
2131908
060Y
8/1/1963
F
H
RT. KNEE
5/30/2000 19:16:59
S000269
LOC: -27.12
THK: 3.50
FFS
A
P
KNEE QUAD
SE
FA: 90
TR: 2500
TE: 25
C: 389
W: 750

Head CT, showing area of interest function


edon, Summer H
5113
Y
4/1960
A
HEAD W/O
4/19/2001 07:55:31
S000220
LOC: 44.50
THK: 10
HFS
11:1
L
A: 518.30mm²
M: 29.94 HU
SD: 4.08 HU
250
22
180
120
No: 13
C: 40
W: 80
e: 13 of 23
P
IM: 13 SE: 2

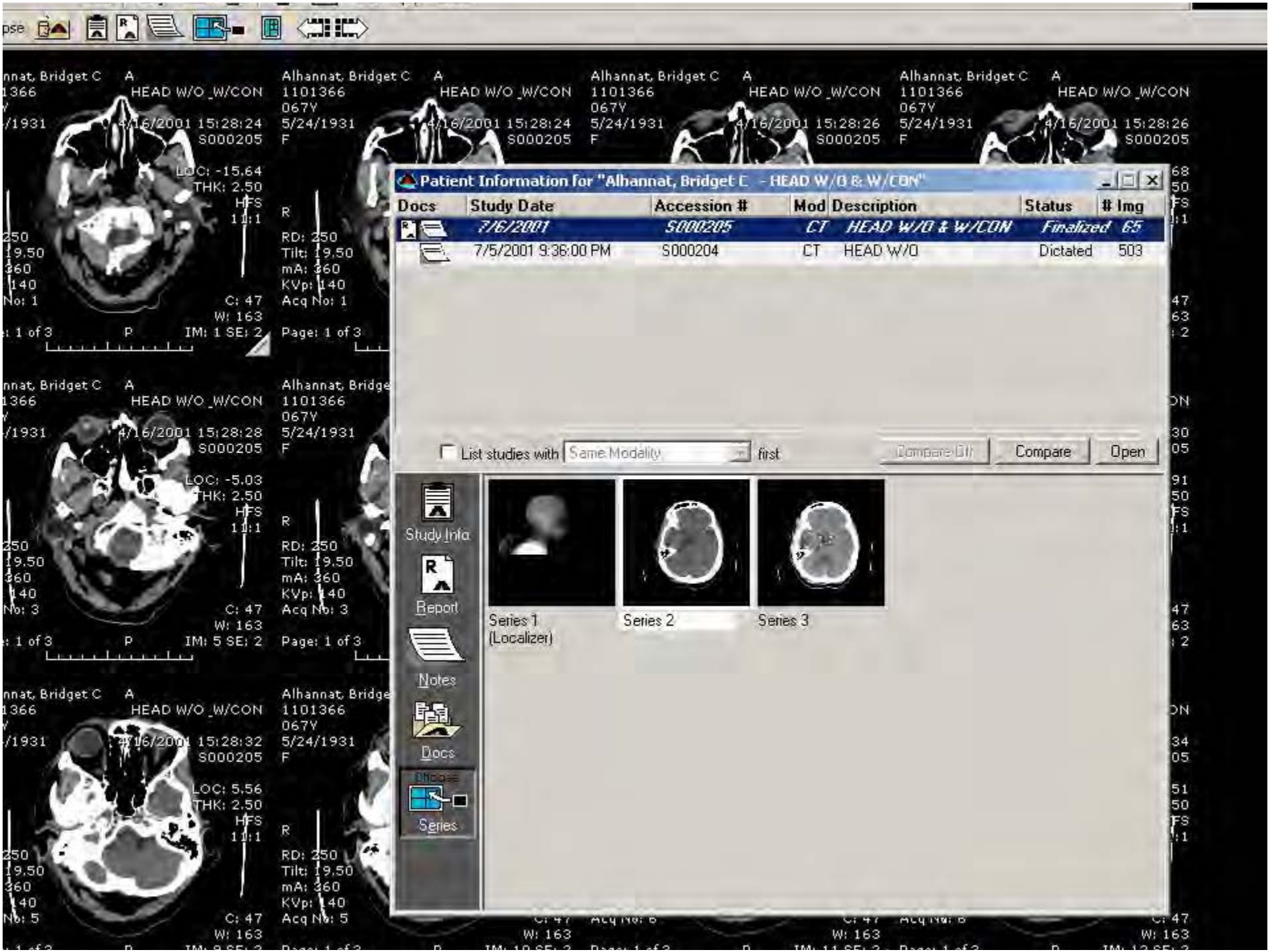
CT head, ‘tiling’ hanging protocol


Incledon, Summer H A
8105113
078Y
3/24/1960
F
HEAD W/O
4/19/2001 07:55:02
S000220
LOC: 4.50
THK: 5
HFS
11:1
RD: 250
Tilt: 22
mA: 180
KVp: 140
Acq No: 5
C: 40
W: 100
Page: 1 of 2
P
IM: 5 SE: 2
4/19/2001 07:55:05
LOC: 9.50
Acq No: 6
IM: 6 SE: 2
4/19/2001 07:55:08
LOC: 14.50
Acq No: 7
IM: 7 SE: 2
4/19/2001 07:55:11
LOC: 19.50
Acq No: 8
IM: 8 SE: 2
4/19/2001 07:55:14
LOC: 24.50
Acq No: 9
IM: 9 SE: 2
4/19/2001 07:55:17
LOC: 29.50
Acq No: 10
IM: 10 SE: 2
4/19/2001 07:55:20
LOC: 34.50
Acq No: 11
IM: 11 SE: 2
4/19/2001 07:55:23
LOC: 39.50
Acq No: 12
IM: 12 SE: 2
4/19/2001 07:55:31
LOC: 44.50
THK: 10
W: 80
518.30mm²
29.94 HU
4.08 HU
Acq No: 13
4/19/2001 07:55:34
LOC: 54.50
Acq No: 14
4/19/2001 07:55:37
LOC: 64.50
Acq No: 15
4/19/2001 07:55:40
LOC: 74.50
Acq No: 16

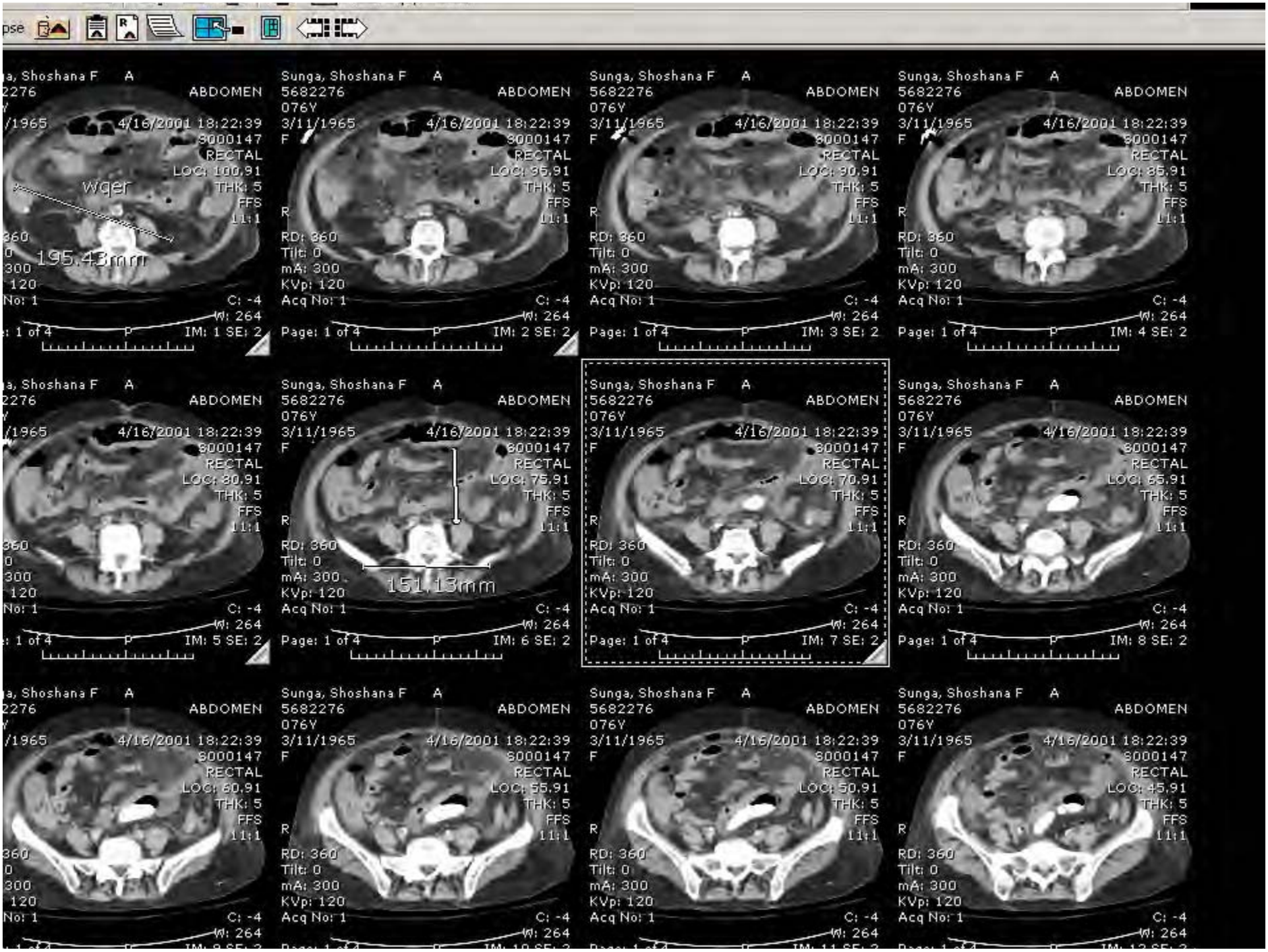
Head CT, showing pull down menu for choosing presets


Window Level
Zoom
Pan
Ruler R
Text T
Arrow A
Density Value D
Lock Tools L
Image Presets
Scale, Rotate, Flip
Tools
Reference Lines
Apply Tools
Save Image
AON Factor
Copy To Clipboard
Tile Formats
IntelliLink I
IntelliScroll S
IntelliScroll Add/Remove K
IntelliScroll - Remove All C
Cine...
Print...
Bone NUMPAD 0
Abdomen NUMPAD 1
Lung NUMPAD 2
BRAIN NUMPAD 3
Liver NUMPAD 5
Spines NUMPAD 4
Scout NUMPAD 6
Revert NUMPAD 9
Invert

CT head, showing menu for choosing image series


Patient Information for "Alhannat, Bridget C - HEAD W/O & W/CON"
Docs
Study Date
Accession #
Mod
Description
Status
Img
7/6/2001
S000205
CT
HEAD W/O & W/CON
Finalized
65
7/5/2001 9:36:00 PM
S000204
CT
HEAD W/O
Dictated
503
List studies with
Same Modality
first
Compare On
Compare
Open
Study Info
Report
Notes
Docs
Series
Series 1
(Localizer)
Series 2
Series 3
Alhannat, Bridget C A
1101366
HEAD W/O _W/CON
067Y
5/24/1931
F
4/16/2001 15:28:24
S000205
LOC: -15.64
THK: 2.50
HFS
11:1
RD: 250
Tilt: 19.50
mA: 360
KVp: 140
Acq No: 1
C: 47
W: 163
Page: 1 of 3
4/16/2001 15:28:26
LOC: -5.03
Acq No: 3
4/16/2001 15:28:28
IM: 5 SE: 2
4/16/2001 15:28:32
LOC: 5.56
Acq No: 5

CT abdomen, ‘tiling’ hanging protocol


Sunga, Shoshana F A
5682276
076Y
3/11/1965 F
ABDOMEN
4/16/2001 18:22:39
S000147
RECTAL
LOC: 100.91
LOC: 95.91
LOC: 90.91
LOC: 85.91
LOC: 80.91
LOC: 75.91
LOC: 70.91
LOC: 65.91
LOC: 60.91
LOC: 55.91
LOC: 50.91
LOC: 45.91
THK: 5
FFS
11:1
R
RD: 360
Tilt: 0
mA: 300
KVp: 120
Acq No: 1
C: -4
W: 264
wqer
195.43mm
151.13mm
Page: 1 of 4
IM: 1 SE: 2
IM: 2 SE: 2
IM: 3 SE: 2
IM: 4 SE: 2
IM: 5 SE: 2
IM: 6 SE: 2
IM: 7 SE: 2
IM: 8 SE: 2

PACS training is necessary for optimum patient care

Ref 3

Goals of PACS education c. 1990

- Learn to retrieve images and reports and display them on a workstation
- Learn to use the workstation tools to enhance the images

Refs 3, 13

Goals of PACS education c. 1995

- All of the above, plus…

- Customize the workstation to the user's preference
  - Hanging protocols
  - Image orientation
- Interface the PACS with the radiology information system (RIS)
  - Worklists
  - Exam schedules

Ref 13

PACS training should be tailored to the requirements of the different physician and surgical specialties

Ref 3

PACS training should be carried out individually or in small groups (same specialty)

Ref 3

Clinician training - 1 hour (30 -45 minutes of demonstration, 15 - 30 minutes of hands on experience

Ref 3

Paradigm shift in viewing techniques

- Multiple viewboxes vs one or two monitors
- Use bright light vs change contrast function on workstation
- Hold film vs hold mouse

Paradigm shift …

- Use hand held magnifying glass vs use magnify function on workstation
- Measure distances and angles with ruler and goniometer vs measure distances and angles with measuring functions on workstation

Paradigm shift …

- Draw on image with wax pencil vs annotate image using keyboard and / or draw function on workstation
- Remove film from jacket for future use vs access images from office or home PC via secure internet connection and / or burn a CD

Paradigm shift …

- Search through folder for the previous films vs previous studies automatically displayed along with the current study

Viewing habits

- Early on, people use ‘tile mode’ for viewing CT’s. This reflects their experience with hard copy film.
- After using PACS for a while, most people view CT’s in ‘stack mode’
- Interpretation of CT’s is more rapid when viewed in ‘stack mode’

Ref 25

Conclusion

PACS requires a change in the way we view images, but provides improved workflow, improved throughput, improved accessibility to images, ability to manipulate images, and improved communication capability, all geared to the goal of improving patient care.

Robert H. Posteraro, M.D.
rhpos@earthlink.net

PACS Workstations

Workstations

- High resolution monitors (‘standard’ is 2 megapixels, but can be up to 4 megapixels)
- Increased resolution --> increased cost
- 1, 2, 4 or 8 monitors?

Viewing Workstation

- Receives the images
- Presents the images for viewing
- Has image processor functions available

Ref 13

Workstation functions

- Change contrast
- Invert gray scale
- Flip
- Rotate
- Magnify

Workstation functions cont'd …

- Pan
- Zoom
- Measure
  - Linear distance, area, angle, density

Workstation functions cont'd …

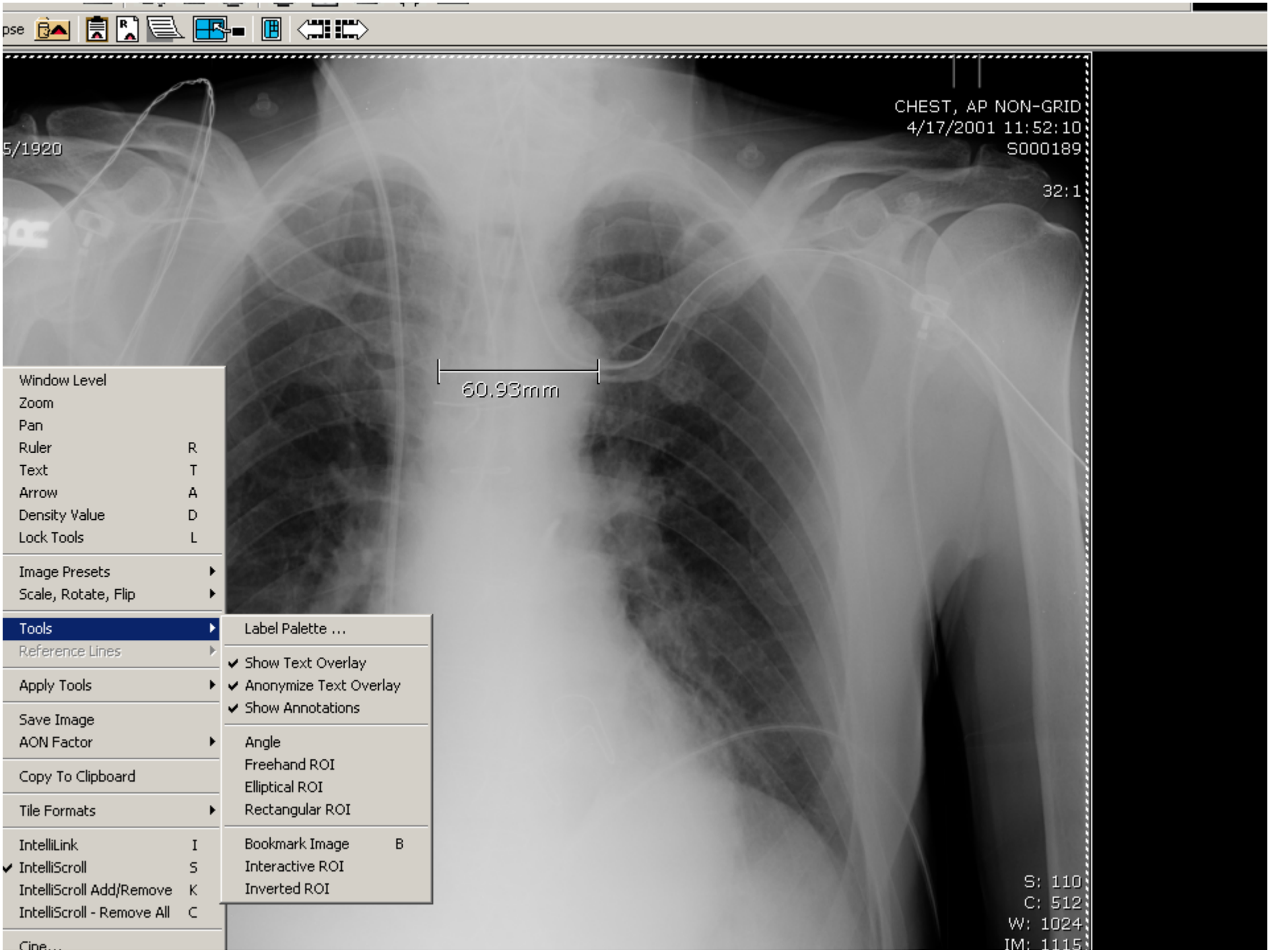
- Set individual preferences
  - Hanging protocols
  - Image orientation
- Worklists
- Automatic retrieval of comparison images

PACS screen images
provided courtesy of

FUJIFILM Medical Systems
USA, Inc.

With deepest appreciation to
Betty Assadullahi
FUJIFILM Medical Systems
USA, Inc.

Chest image with tool bar and pull down menus


CHEST, AP NON-GRID
4/17/2001 11:52:10
S000189
32:1
60.93mm
S: 110
C: 512
W: 1024
Window Level
Zoom
Pan
Ruler R
Text T
Arrow A
Density Value D
Lock Tools L
Image Presets
Scale, Rotate, Flip
Tools
Reference Lines
Apply Tools
Save Image
AON Factor
Copy To Clipboard
Tile Formats
IntelliLink I
IntelliScroll S
IntelliScroll Add/Remove K
IntelliScroll - Remove All C
Label Palette ...
Show Text Overlay
Anonymize Text Overlay
Show Annotations
Angle
Freehand ROI
Elliptical ROI
Rectangular ROI
Bookmark Image B
Interactive ROI
Inverted ROI

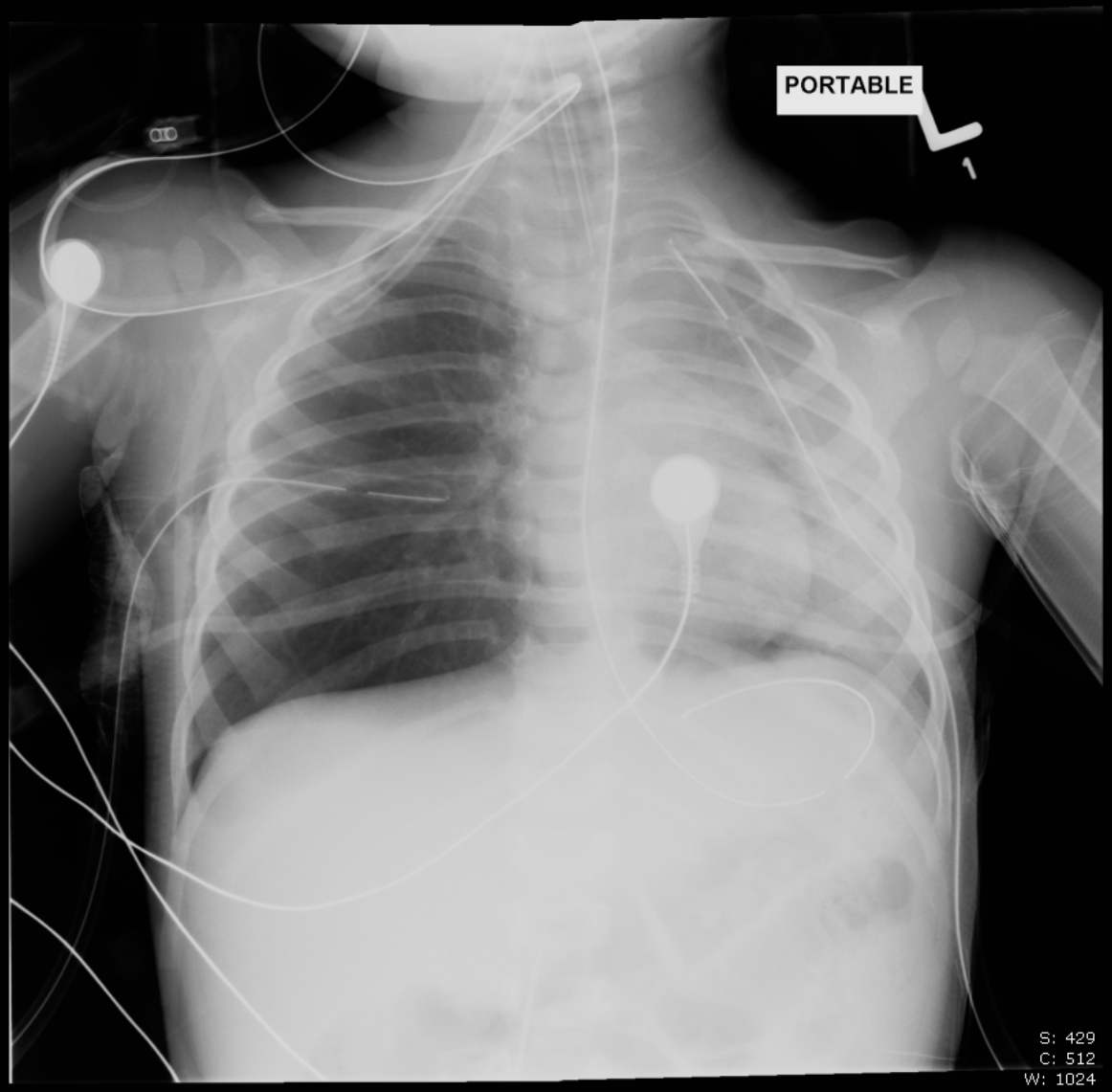
Chest image, uncompressed

Montana, Joe
9000009

11/5/1968
M

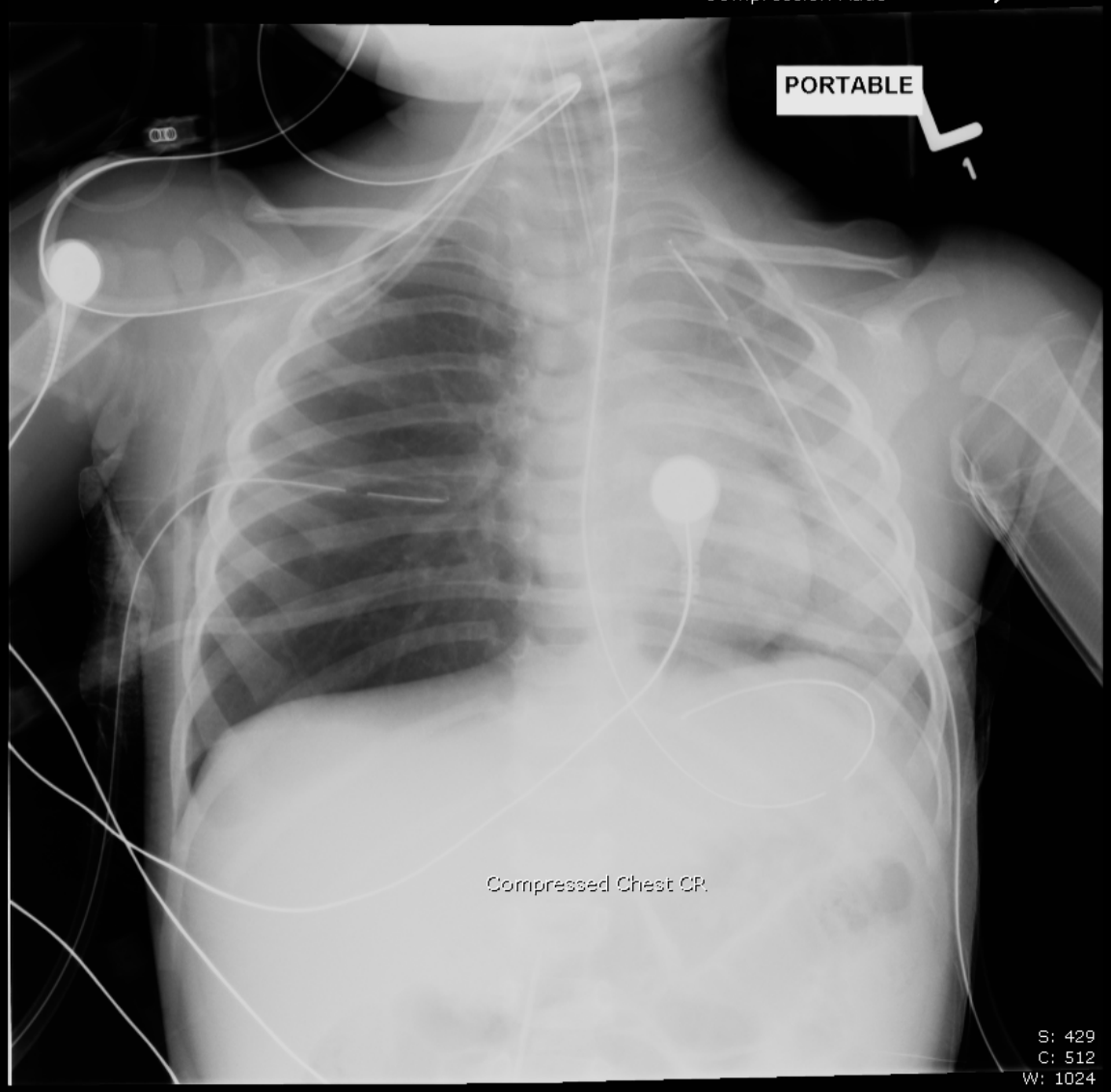
CHEST
10/14/2001 03:10:33
G000026

Uncompressed CR Chest

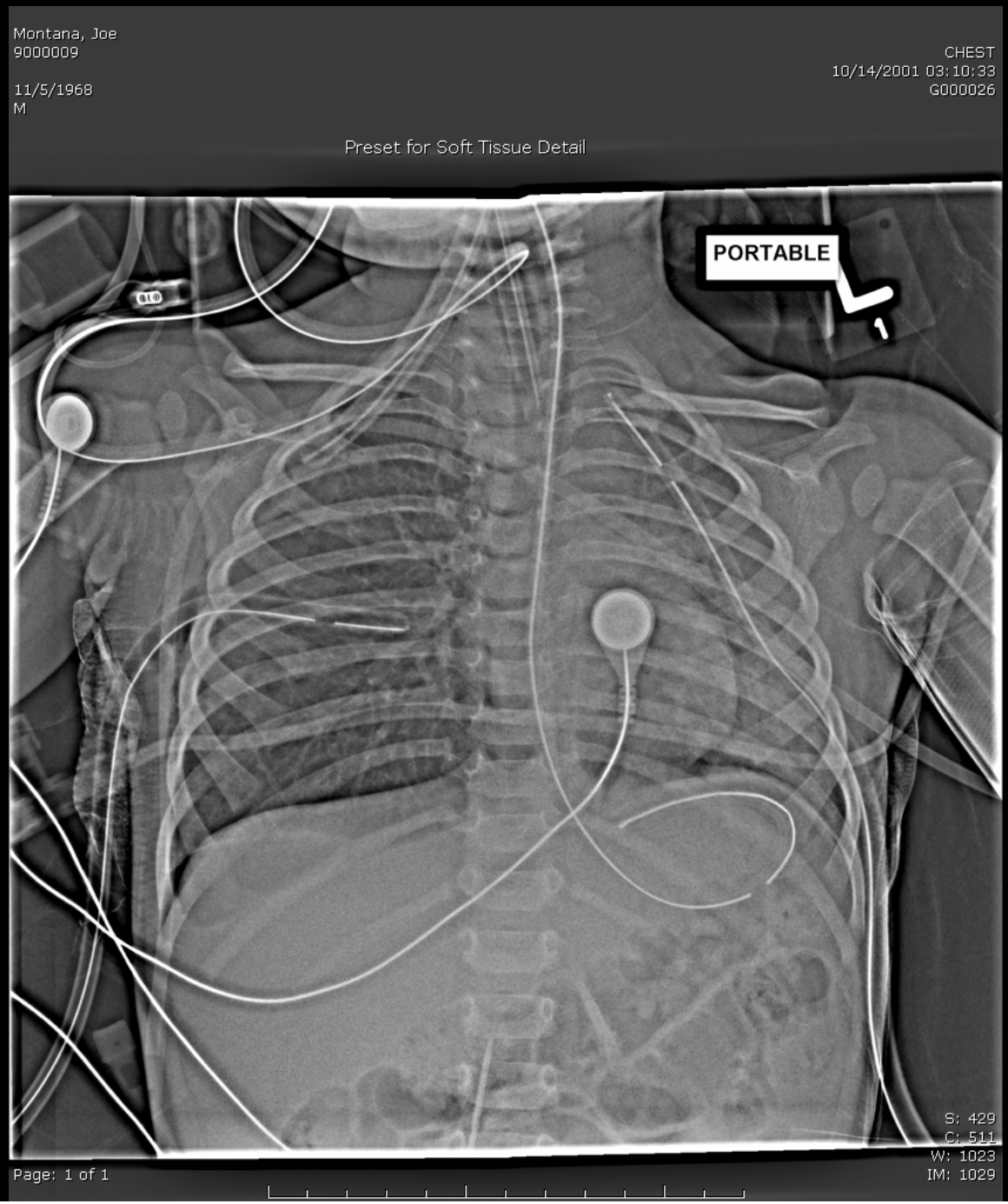


S: 429
C: 512
W: 1024
IM: 1029

Chest image, compressed 32:1


Montana, Joe
9000009
11/5/1968
M
CHEST
10/14/2001 03:10:33
G000026
32:1
Compression Ratio
PORTABLE
Compressed Chest CR
S: 429
C: 512
W: 1024
IM: 1029
Page: 1 of 1

Chest image, soft tissue detail


Montana, Joe
9000009
11/5/1968
M
CHEST
10/14/2001 03:10:33
G000026
Preset for Soft Tissue Detail
PORTABLE
S: 429
C: 511
W: 1023
IM: 1029
Page: 1 of 1

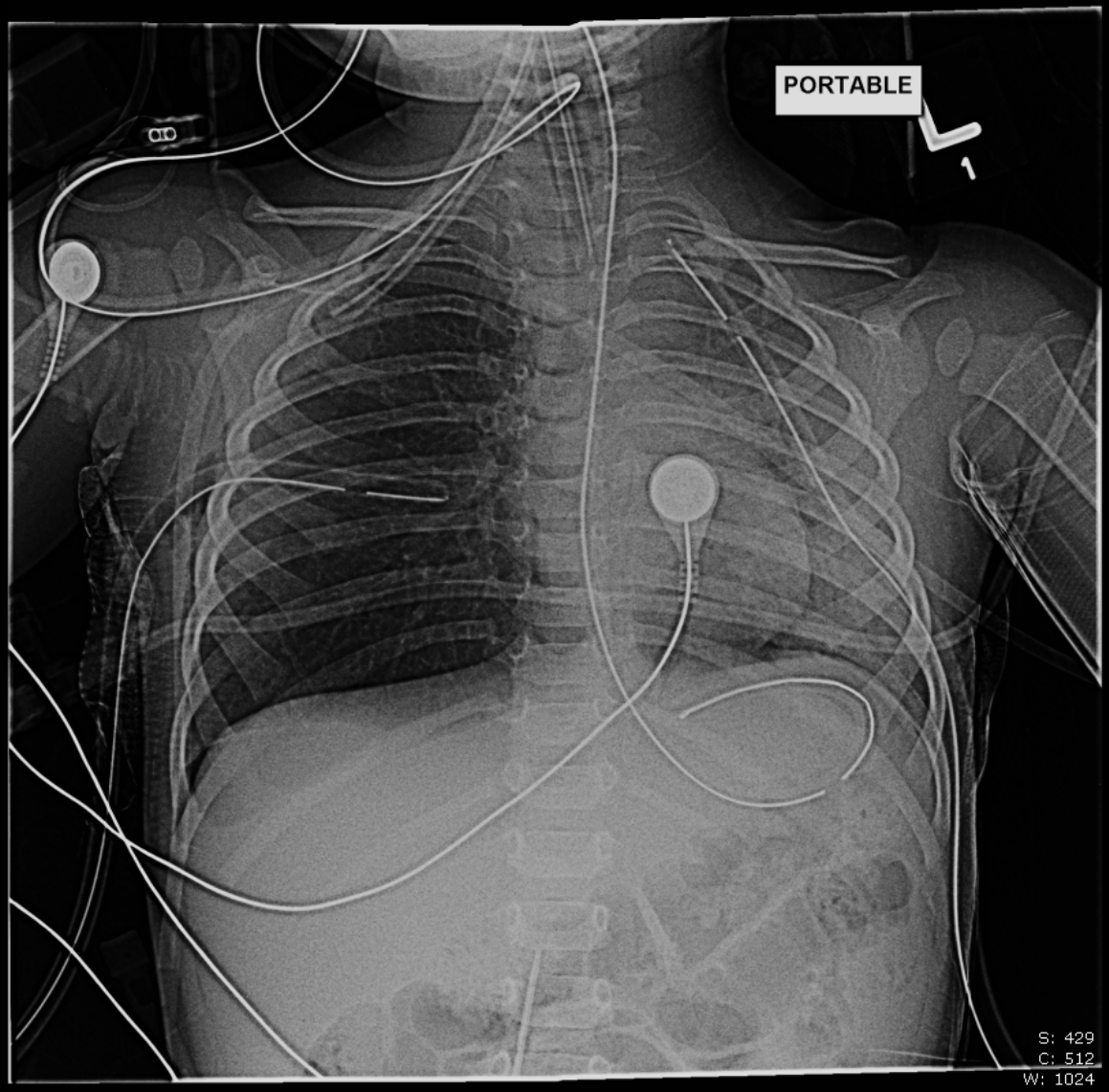
Chest image, line placement

Montana, Joe
9000009

11/5/1968
M

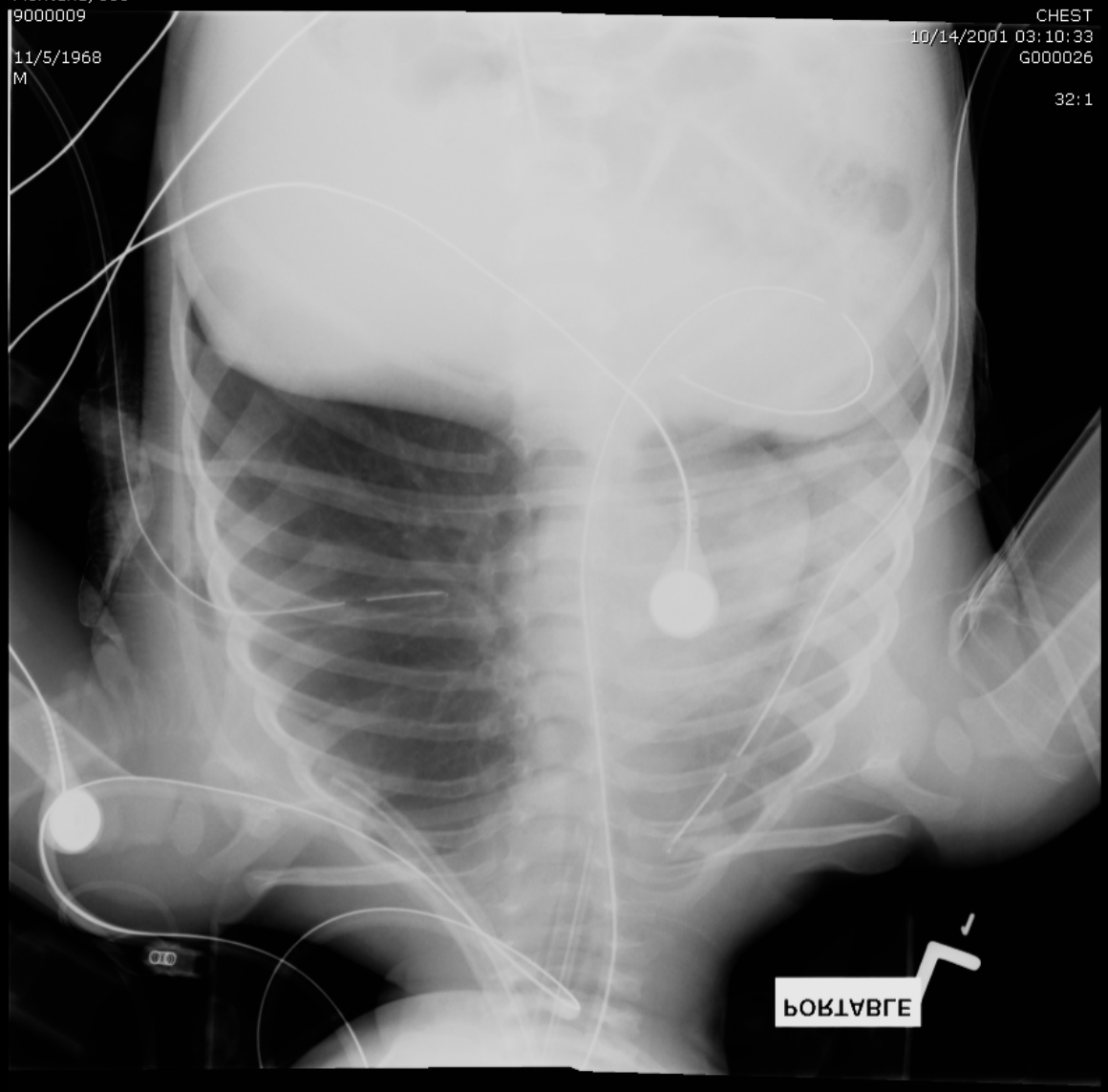
CHEST
10/14/2001 03:10:33
G000026

Preset for Chest Line Placement



S: 429
C: 512
W: 1024
IM: 1029

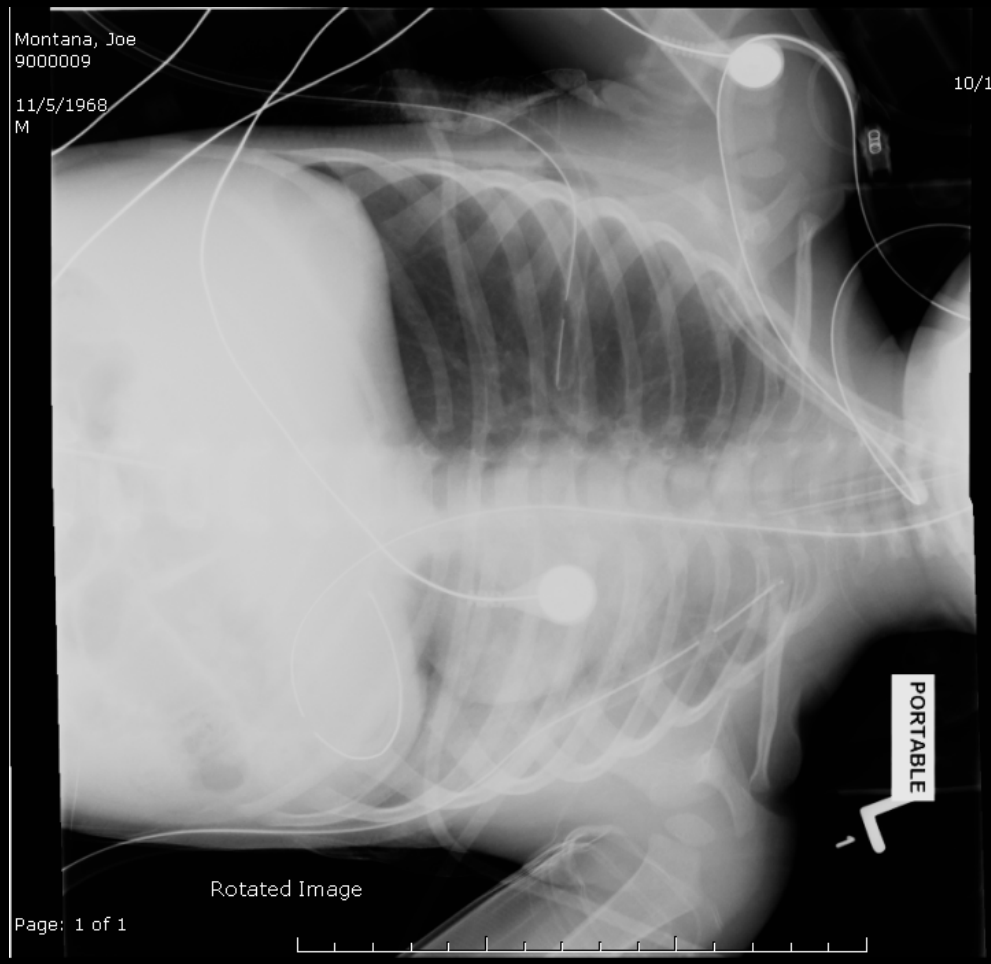
Chest image, examples of ‘flip’ function



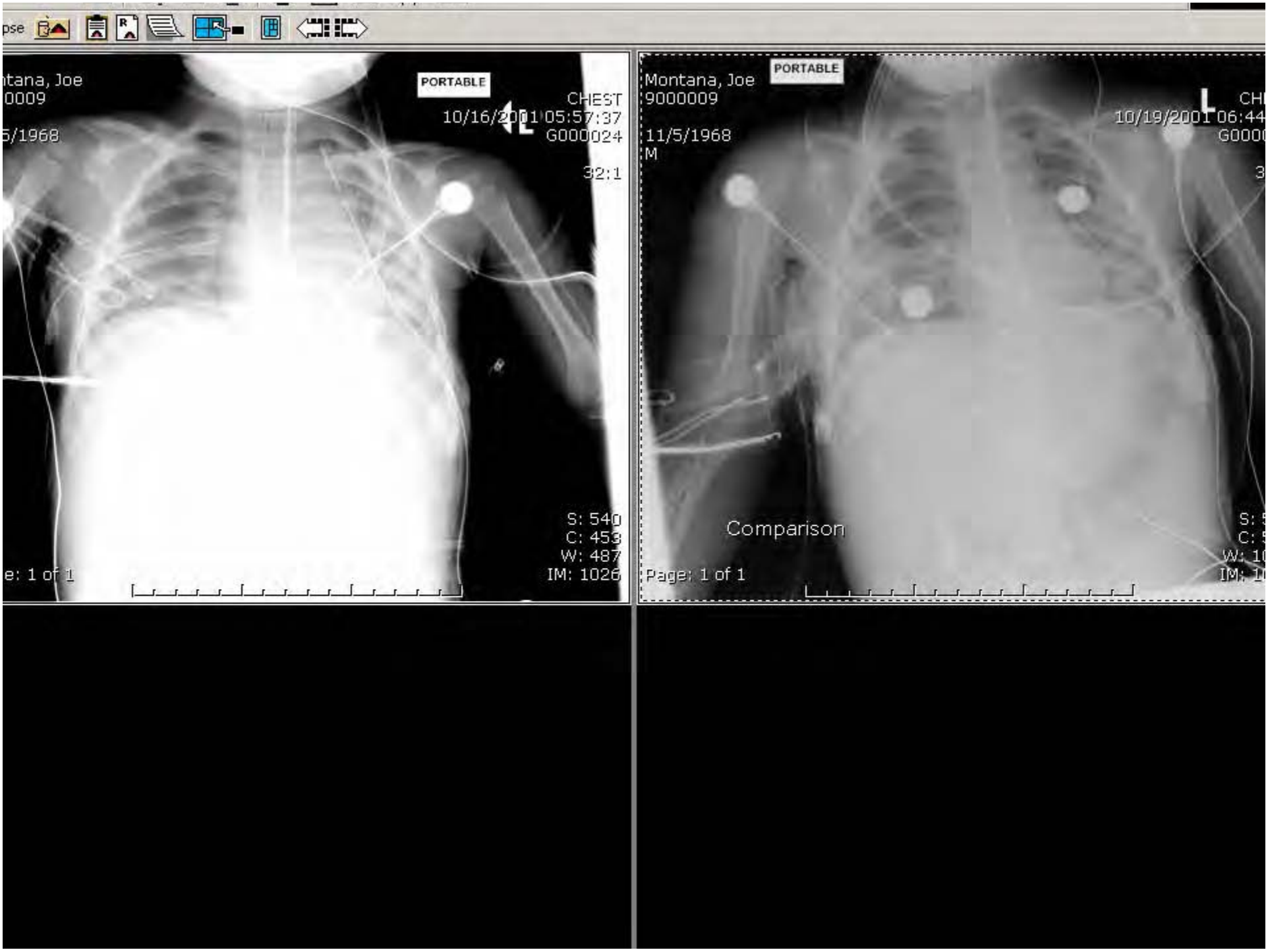
Flipped Image

S: 429
C: 512
W: 1024
IM: 1029

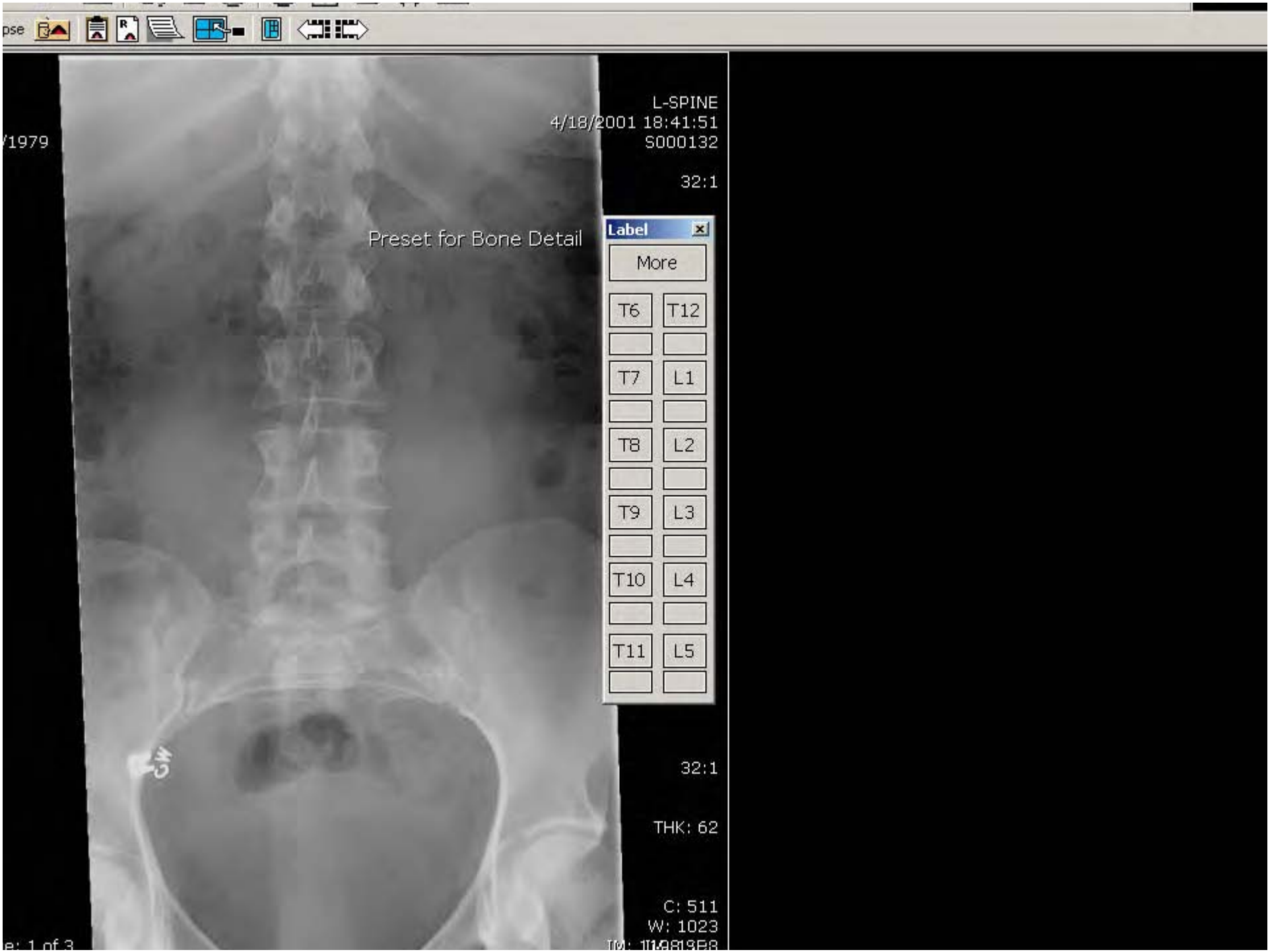
Page: 1 of 1


Montana, Joe
9000009
11/5/1968
M
CHEST
10/14/2001 03:10:33
G000026
32:1
PORTABLE
Rotated Image
Page: 1 of 1
S: 429
C: 512
W: 1024
IM: 1029

Chest images, side by side comparison hanging protocol


PORTABLE
CHEST
10/16/2001 05:57:37
G0000024
32:1
S: 540
C: 453
W: 487
IM: 1026
Page: 1 of 1
PORTABLE
Montana, Joe
9000009
11/5/1968
M
10/19/2001 06:44
Comparison
Page: 1 of 1

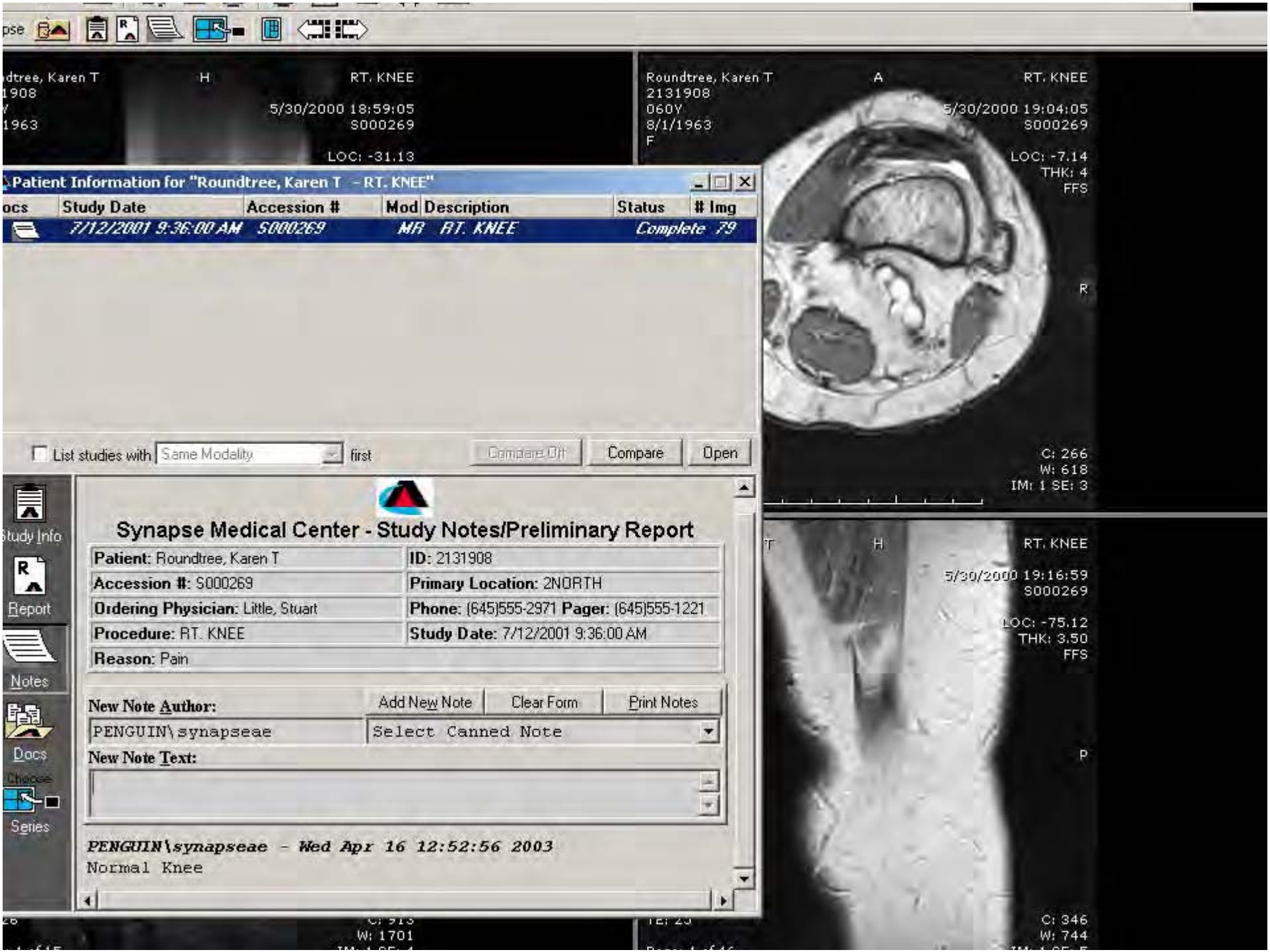
L-spine, bone detail


/1979
L-SPINE
4/18/2001 18:41:51
S000132
32:1
Preset for Bone Detail
Label
More
T6
T12
T7
L1
T8
L2
T9
L3
T10
L4
T11
L5
32:1
THK: 62
C: 511
W: 1023

Foot, showing magnification function and cm scale


FOOT
10/23/2001 19:56:22
G000028
S: 61
C: 512
W: 1024

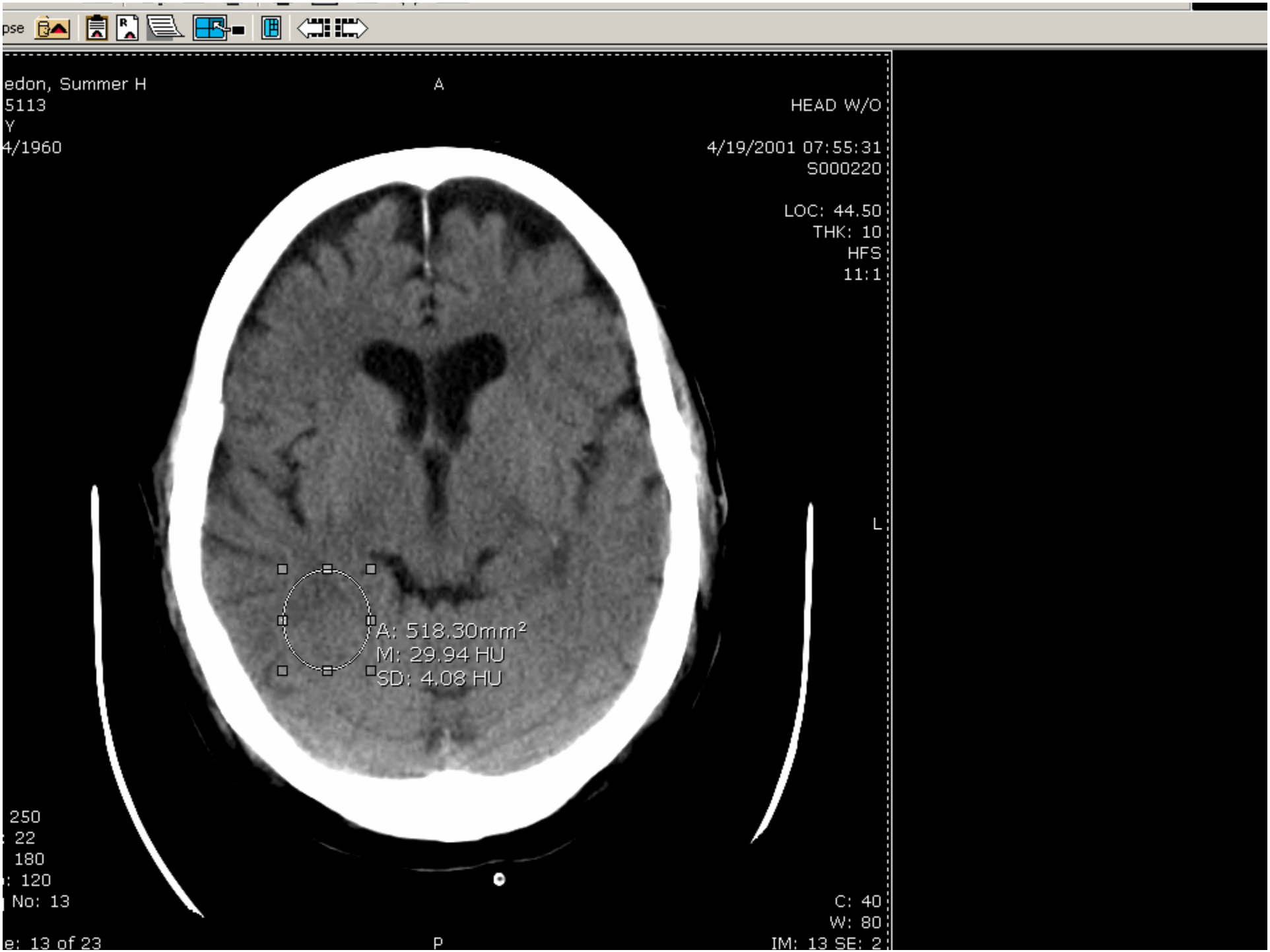
MRI image, showing patient information and ‘note’ function


dtree, Karen T
1908
1963
H
RT. KNEE
5/30/2000 18:59:05
S000269
LOC: -31.13
Roundtree, Karen T
2131908
060Y
8/1/1963
F
A
RT. KNEE
5/30/2000 19:04:05
S000269
LOC: -7.14
THK: 4
FFS
R
C: 266
W: 618
IM: 1 SE: 3
Patient Information for "Roundtree, Karen T - RT. KNEE"
ocs
Study Date
Accession #
Mod
Description
Status
Img
7/12/2001 9:36:00 AM
S000269
MR
RT. KNEE
Complete
79
List studies with
Same Modality
first
Compare Off
Compare
Open
Study Info
Report
Notes
Docs
Choose Series
Synapse Medical Center - Study Notes/Preliminary Report
Patient: Roundtree, Karen T
ID: 2131908
Accession #: S000269
Primary Location: 2NORTH
Ordering Physician: Little, Stuart
Phone: (645)555-2971 Pager: (645)555-1221
Procedure: RT. KNEE
Study Date: 7/12/2001 9:36:00 AM
Reason: Pain
New Note Author:
Add New Note
Clear Form
Print Notes
PENGUIN\synapseae
Select Canned Note
New Note Text:
PENGUIN\synapseae - Wed Apr 16 12:52:56 2003
Normal Knee
T
H
RT. KNEE
5/30/2000 19:16:59
S000269
LOC: -75.12
THK: 3.50
FFS
P
C: 346
W: 744
W: 1701

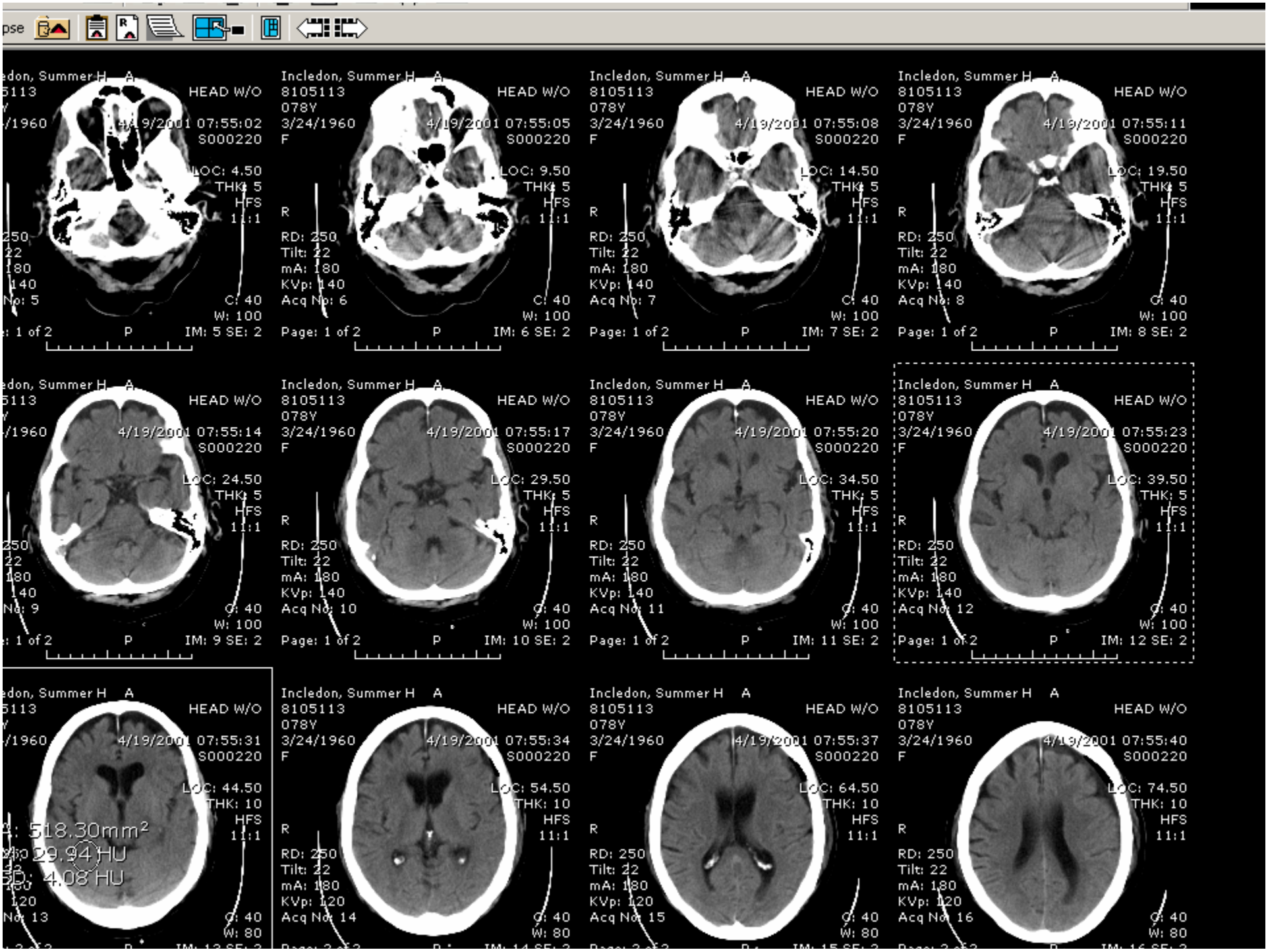
Knee MRI, showing multiple sequence hanging protocol and plane of interest function


dtree, Karen T
1908
1963
H
RT. KNEE
5/30/2000 18:59:05
S000269
LOC: -31.13
THK: 10
FFS
P
E QUAD
20
10
4
C: 388
W: 806
: 1 of 3
IM: 1 SE: 2
Roundtree, Karen T
2131908
060Y
8/1/1963
F
A
RT. KNEE
5/30/2000 19:04:05
S000269
LOC: -7.14
THK: 4
FFS
L
R
KNEE QUAD
FE
FA: 35
TR: 660
TE: 15
C: 266
W: 618
Page: 1 of 15
45
25
1
M: 1 SE: 3
dtree, Karen T
1908
1963
H
RT. KNEE
5/30/2000 19:08:21
S000269
LOC: -36.28
THK: 4
FFS
L
E QUAD
90
2000
26
C: 913
W: 1701
1
25
45
Roundtree, Karen T
2131908
060Y
8/1/1963
F
H
RT. KNEE
5/30/2000 19:16:59
S000269
LOC: -27.12
THK: 3.50
FFS
A
P
KNEE QUAD
SE
FA: 90
TR: 2500
TE: 25
C: 389
W: 750

Head CT, showing area of interest function


edon, Summer H
5113
Y
4/1960
A
HEAD W/O
4/19/2001 07:55:31
S000220
LOC: 44.50
THK: 10
HFS
11:1
L
A: 518.30mm²
M: 29.94 HU
SD: 4.08 HU
250
22
180
120
No: 13
C: 40
W: 80
e: 13 of 23
P
IM: 13 SE: 2

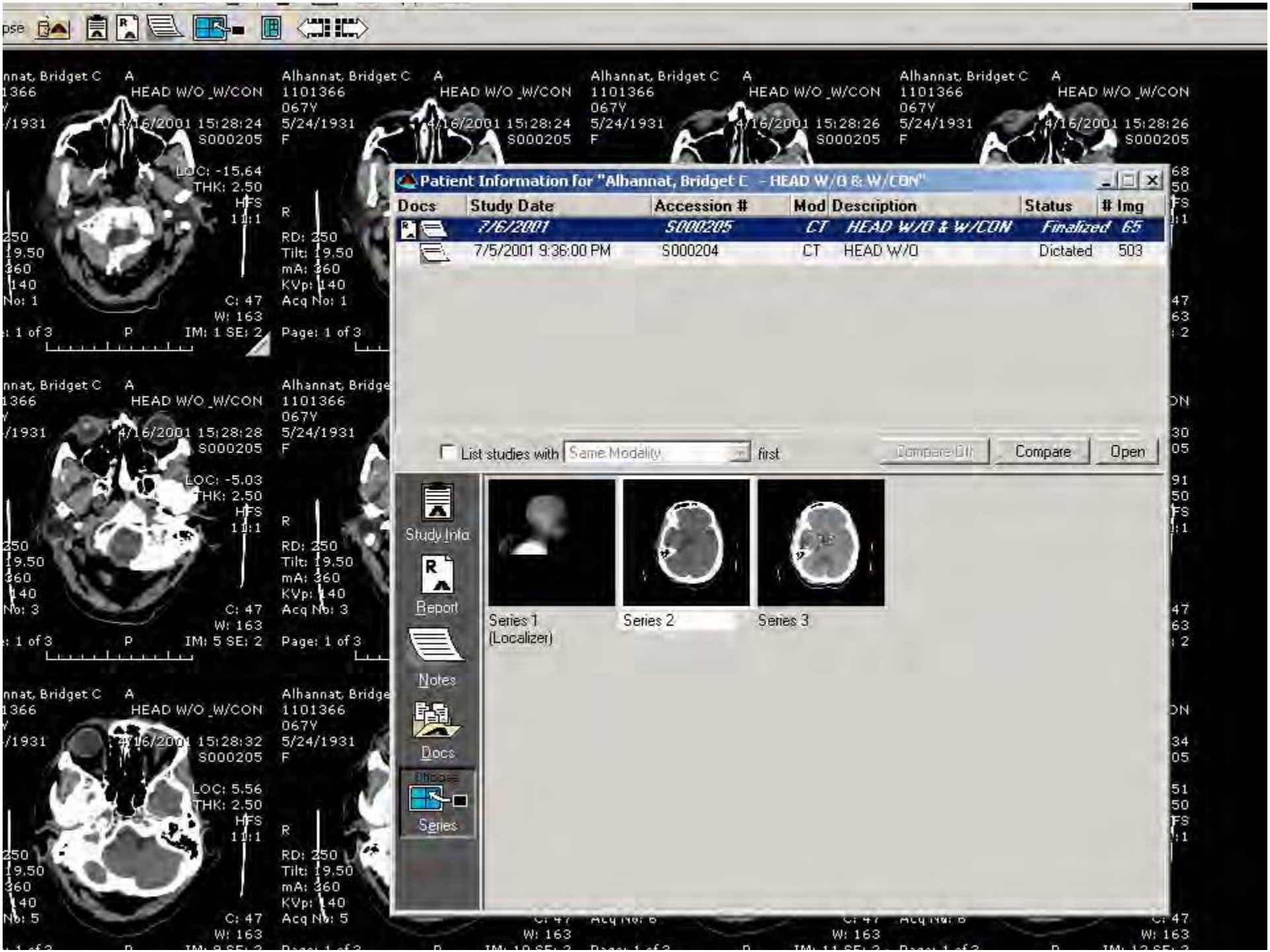
CT head, ‘tiling’ hanging protocol


Incledon, Summer H A
8105113
078Y
3/24/1960
F
HEAD W/O
4/19/2001 07:55:02
S000220
LOC: 4.50
THK: 5
HFS
11:1
RD: 250
Tilt: 22
mA: 180
KVp: 140
Acq No: 5
C: 40
W: 100
Page: 1 of 2
P
IM: 5 SE: 2
4/19/2001 07:55:05
LOC: 9.50
Acq No: 6
IM: 6 SE: 2
4/19/2001 07:55:08
LOC: 14.50
Acq No: 7
IM: 7 SE: 2
4/19/2001 07:55:11
LOC: 19.50
Acq No: 8
IM: 8 SE: 2
4/19/2001 07:55:14
LOC: 24.50
Acq No: 9
IM: 9 SE: 2
4/19/2001 07:55:17
LOC: 29.50
Acq No: 10
IM: 10 SE: 2
4/19/2001 07:55:20
LOC: 34.50
Acq No: 11
IM: 11 SE: 2
4/19/2001 07:55:23
LOC: 39.50
Acq No: 12
IM: 12 SE: 2
4/19/2001 07:55:31
LOC: 44.50
THK: 10
W: 80
518.30mm²
29.94 HU
4.08 HU
Acq No: 13
4/19/2001 07:55:34
LOC: 54.50
Acq No: 14
4/19/2001 07:55:37
LOC: 64.50
Acq No: 15
4/19/2001 07:55:40
LOC: 74.50
Acq No: 16

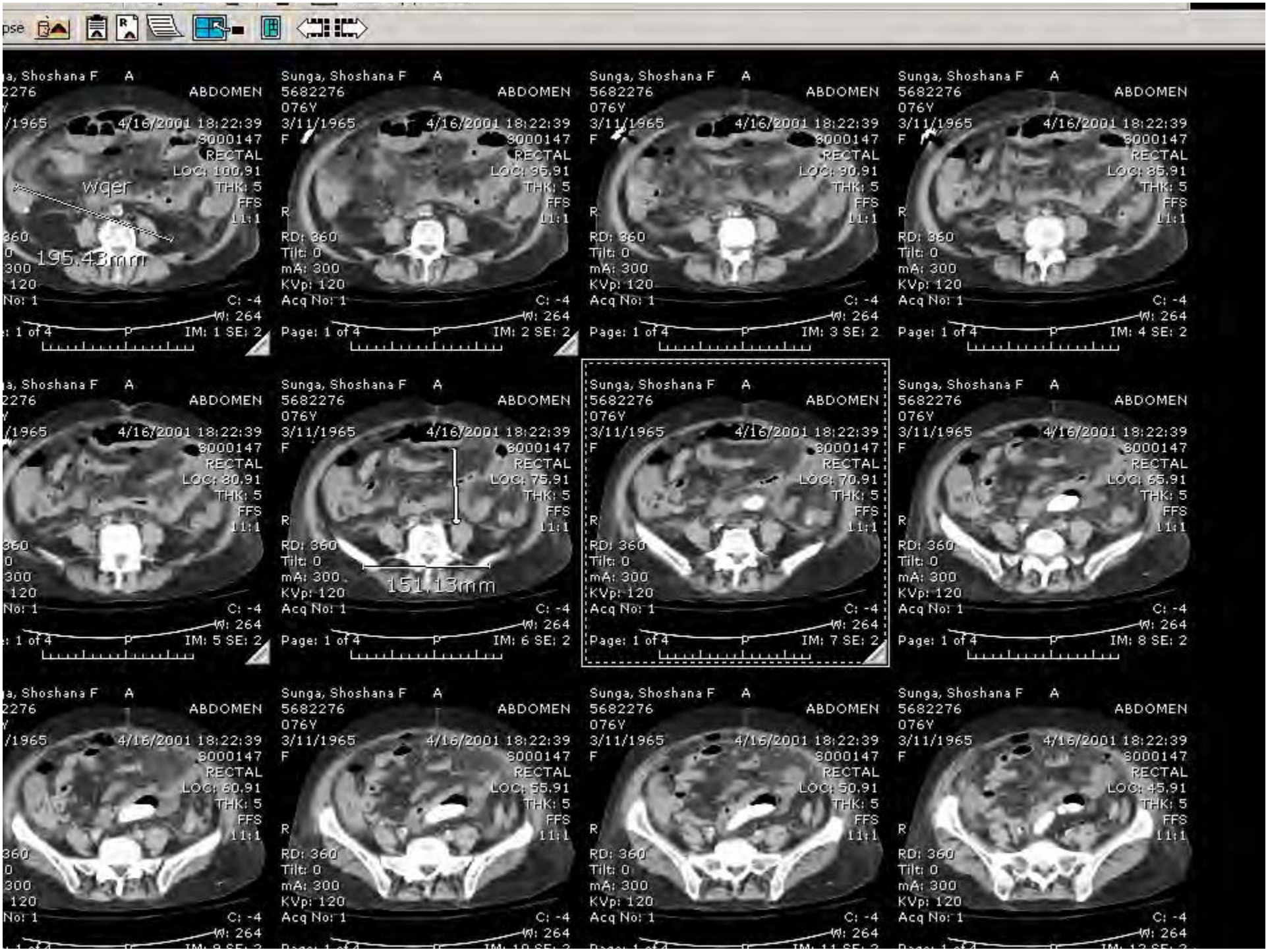
Head CT, showing pull down menu for choosing presets


Window Level
Zoom
Pan
Ruler R
Text T
Arrow A
Density Value D
Lock Tools L
Image Presets
Scale, Rotate, Flip
Tools
Reference Lines
Apply Tools
Save Image
AON Factor
Copy To Clipboard
Tile Formats
IntelliLink I
IntelliScroll S
IntelliScroll Add/Remove K
IntelliScroll - Remove All C
Cine...
Print...
Bone NUMPAD 0
Abdomen NUMPAD 1
Lung NUMPAD 2
BRAIN NUMPAD 3
Liver NUMPAD 5
Spines NUMPAD 4
Scout NUMPAD 6
Revert NUMPAD 9
Invert

CT head, showing menu for choosing image series


Patient Information for "Alhannat, Bridget C - HEAD W/O & W/CON"
Docs
Study Date
Accession #
Mod
Description
Status
Img
7/6/2001
S000205
CT
HEAD W/O & W/CON
Finalized
65
7/5/2001 9:36:00 PM
S000204
CT
HEAD W/O
Dictated
503
List studies with
Same Modality
first
Compare On
Compare
Open
Study Info
Report
Notes
Docs
Series
Series 1
(Localizer)
Series 2
Series 3
Alhannat, Bridget C A
1101366
HEAD W/O _W/CON
067Y
5/24/1931
F
4/16/2001 15:28:24
S000205
LOC: -15.64
THK: 2.50
HFS
11:1
RD: 250
Tilt: 19.50
mA: 360
KVp: 140
Acq No: 1
C: 47
W: 163
Page: 1 of 3
4/16/2001 15:28:26
LOC: -5.03
Acq No: 3
4/16/2001 15:28:28
IM: 5 SE: 2
4/16/2001 15:28:32
LOC: 5.56
Acq No: 5

CT abdomen, ‘tiling’ hanging protocol


Sunga, Shoshana F A
5682276
076Y
3/11/1965 F
ABDOMEN
4/16/2001 18:22:39
S000147
RECTAL
LOC: 100.91
LOC: 95.91
LOC: 90.91
LOC: 85.91
LOC: 80.91
LOC: 75.91
LOC: 70.91
LOC: 65.91
LOC: 60.91
LOC: 55.91
LOC: 50.91
LOC: 45.91
THK: 5
FFS
11:1
R
RD: 360
Tilt: 0
mA: 300
KVp: 120
Acq No: 1
C: -4
W: 264
wqer
195.43mm
151.13mm
Page: 1 of 4
IM: 1 SE: 2
IM: 2 SE: 2
IM: 3 SE: 2
IM: 4 SE: 2
IM: 5 SE: 2
IM: 6 SE: 2
IM: 7 SE: 2
IM: 8 SE: 2

There is a reduction of 16.2% in the time taken to interpret CT scans with PACS vs film due to the improved software, optimized hanging protocols, preset window and level settings, faster image retrieval, ‘stack mode’ and ‘linked stack mode’ viewing.

Refs 36, 39

There was also an improvement in the sensitivity, specificity and overall accuracy for interpretations of chest, brain and chest/abdomen CT scans viewed with PACS vs hard copy film interpretations.

Ref 39

Reasons for improved CT readings with PACS

- Use of workstation tools aids interpretation
- Use of stack mode to view images

Ref 39

Paradigm shift in viewing techniques

- Multiple viewboxes vs one or two monitors
- Use bright light vs change contrast function on workstation
- Hold film vs hold mouse

Paradigm shift cont'd

- Use hand held magnifying glass vs use magnify function on workstation
- Measure distances and angles with ruler and goniometer vs measure distances and angles with measuring functions on workstation

Paradigm shift cont'd

- Draw on image with wax pencil vs annotate image using keyboard and / or draw function on workstation
- Remove film from jacket for future use vs access images from office or home PC via secure internet connection and / or burn a CD

Paradigm shift cont'd

- Search through folder for the previous films vs previous studies automatically displayed along with the current study

Viewing habits

- Early on, people tend to use ‘tile mode’ for viewing CT’s. This reflects their experience with hard copy film.
- After using PACS for a while, most people view CT’s in ‘stack mode’
- Interpretation of CT’s is more rapid when viewed in ‘stack mode’

Ref 25

Conclusion

PACS requires a change in the way we view images, but provides improved workflow, improved throughput, improved accessibility to images, ability to manipulate images, and improved communication capability, all geared to the goal of improving patient care.

Robert H. Posteraro, M.D.
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PACS for Technologists

Picture
Archiving and
Communications
System

PACS

Digital image acquisition, storage and transmission

PACS differs
from
film based radiography

PACS affects

- Radiologists
- Radiological technologists
- Clinicians
- Nurses
- Hospital administrators
- Film filing personnel

Problems of early digital imaging:

Multiple vendors +
Proprietary systems
= Incompatibility

Enter DICOM

Digital Imaging and Communications in Medicine

DICOM is based on the American College of Radiology (ACR) and National Electrical Manufacturers Association (NEMA) standard

DICOM standardized communications protocols for image and image identification data so that equipment items from different vendors could communicate with each other.
It is a non-proprietary, open architecture standard.

Open architecture - RADICAL CONCEPT!

Different pieces of equipment could communicate with each other, and could share the same patient demographic data from the hospital information system (HIS) or radiology information system (RIS),

- IF -

all the pieces of equipment were DICOM compatible.

What catalyzed PACS?

- Increased number of studies ordered
- Increased number of images per study
- Increased use of personal computers

Advantages of PACS for technologists

- No lost films
- Images can be manipulated
- Decreased repeat rate
- No loss of resolution when images are copied

Technical limitations of early PACS

- Computer equipment was expensive
- Computer memory was limited
- Storage memory was expensive and limited

More limitations …

- Images files are large
- Transmission times were SLOW

And still more limitations …

- High resolution monitors were expensive
- Limited image manipulation functions
- Not user friendly

Administrative limitations

- No positive financial return for the institution
- What if we are the ‘only show in town’?
- Fear of obsolescence

Enter …

- Less expensive computers and monitors
- Less expensive memory
- More user friendly software (GUI)
- More standardized controls (icons)

PACS becomes more feasible

The first institutions to install PACS were governmental institutions (military and Veterans Administration facilities)

Reliable source of funding

Relatively stable patient population

PACS workflow

- Technologist acquires images
- Technologist approves images
- Transmission of images to storage
- Study appears on work list
- Retrieval of images from storage
- Interpretation of images

Technologist productivity

10.8% reduction in productivity in the first year after PACS installation

27.8 increase in productivity beyond the first year after PACS installation

Ref 1

Most of the increase in productivity is in the multi imaging studies (CT, MRI, ultrasound)

Ref 2

Technologist productivity has increased with PACS

- MRI 58%
- CT 30%
- Ultrasound 41%

Ref 7

70% decrease in time for images to be available with PACS vs conventional film imaging

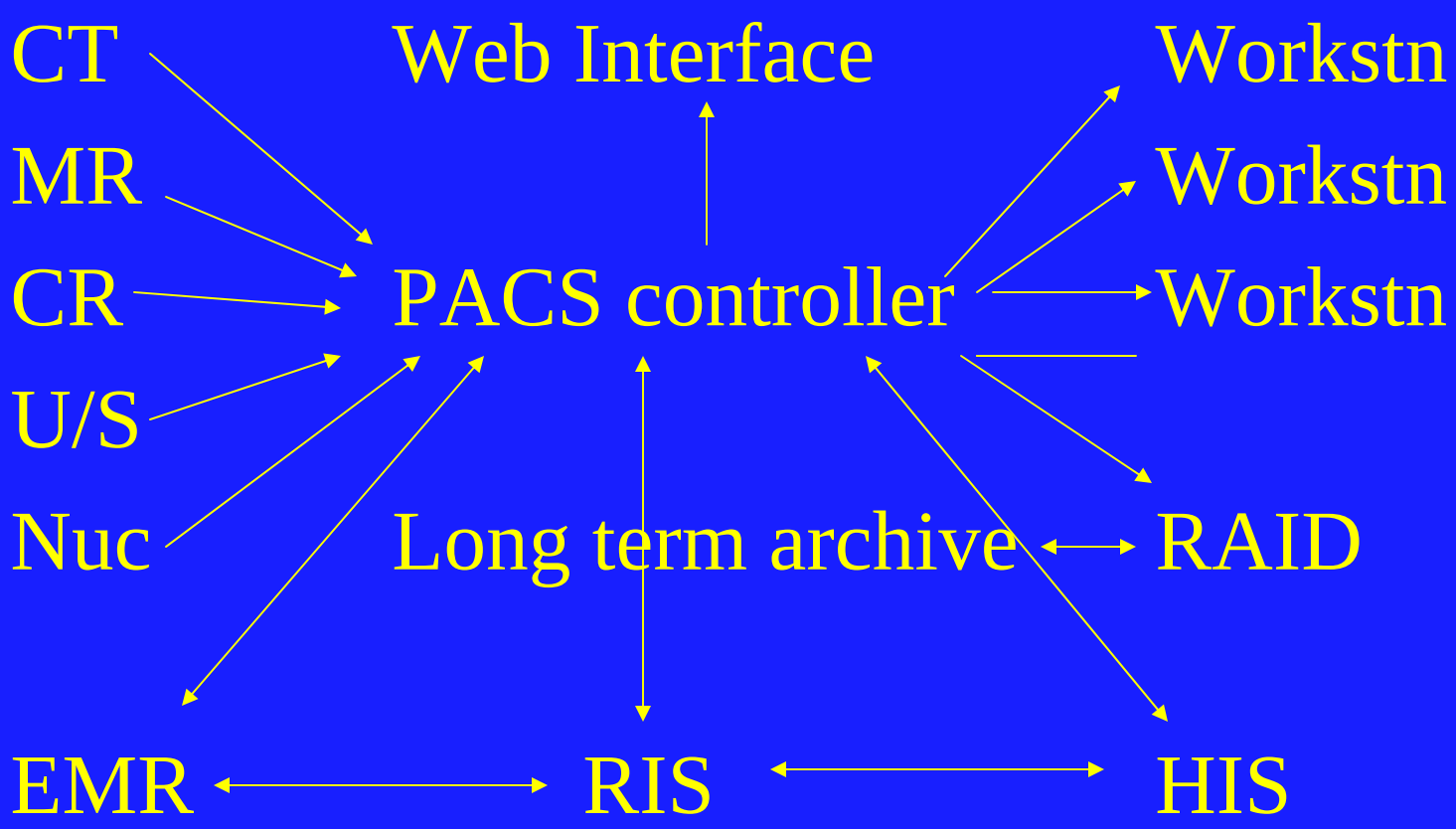
Ref 12

Average time for chest image to be available

- 14.4 minutes from time the first image is taken (range 4 - 49 minutes) for PACS vs
- 47.9 minutes (range 18 - 85 minutes) for conventional film image

Ref 12

The complexity of PACS



All components must function seamlessly

Order of events in PACS

1. The modality acquires the images
2. The DICOM gateway receives images from the modality
3. The DICOM gateway verifies the image format and reformats the images to DICOM format if necessary
4. The DICOM gateway transmits the images to the PACS controller

Ref 13

Order of events cont'd

5. The DICOM gateway verifies that the images have been transmitted successfully
6. If the PACS controller fails to receive the images, the DICOM gateway retains the images until the PACS controller receives them successfully

Ref 13

PACS controller

- Receives and archives the DICOM images
- Is responsible for automatic or on-demand distribution of the images to the viewing workstations
- Transmits the images to the long term archive (RAID)

Ref 13

Viewing Workstation

- Receives the images
- Presents the images for viewing
- Has image processor functions available

Ref 13

RAID

- Stands for ‘Redundant Array of Inexpensive Disks’
- Is the long term archive
- Stores the images indefinitely

Ref 13

Technologists reported lower levels of stress and fatigue after PACS installation, in spite of an increased work load.

Ref 1

Integrating the Healthcare Environment (IHE)

- Began in 1998 with the goal to encourage integration of information systems with the healthcare enterprise
- Data integration with the aim of improving workflow and information sharing in support of better patient care

Ref 13

PACS is a component of IHE

The other components of IHE are

- Hospital information system (HIS)
- Radiology information system (RIS)
- Electronic medical record (EMR)
- Telemedicine network
- Web based health care networks

Ref 13

Conclusion

The increased demands of patient care, technological advancements and the increased expectations of clinicians have resulted in an increase in the workload of radiological technologists. This increased workload can be handled most effectively by applying the improved image handling technology of PACS.

Robert H. Posteraro, M.D.
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The technology of PACS

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Archiving and
Communications
System

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ACR-NEMA standard

- 1983 Established
- 1985 ACR-NEMA standard v1.0
- 1988 v2.0
- 1993 DICOM v3.0
- Continuous evolution

Ref 11

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- Interpretation of images

Workstations

- High resolution monitors (‘standard’ is 2 megapixels, but can be up to 4 megapixels)
- Increased resolution --> increased cost
- 1, 2, 4 or 8 monitors?

Workstation functions

- Change contrast
- Invert gray scale
- Flip
- Rotate
- Magnify

Workstation functions cont'd …

- Pan
- Zoom
- Measure
  - Linear distance, area, angle, density

Workstation functions cont'd …

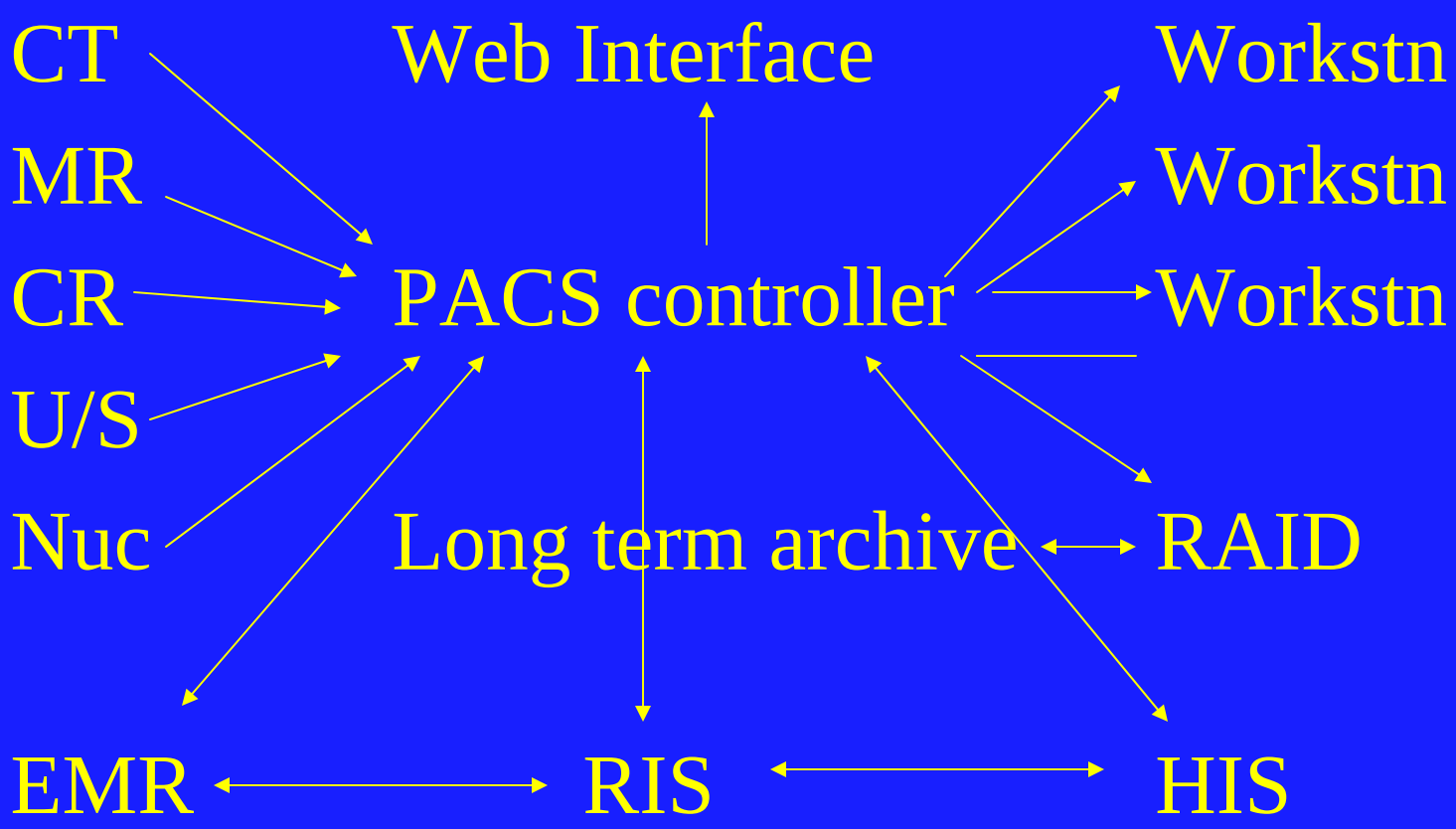
- Set individual preferences
- Choice of hanging protocols
- Automatic retrieval of comparison images

Web access to images and reports

- Secure socket layer (SSL) guarantees integrity of data and confidentiality between client and server
- 128 bit encryption
- Ensure that the user has access only to data that he/she actually needs

Ref 9

The complexity of PACS



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- Is the long term archive
- Stores the images indefinitely

Ref 13

PACS storage requirements

On the order of several terabytes per year for an average sized hospital

Ref 14

Kilo 1,000

Mega 1,000,000

Giga 1,000,000,000

Tera 1,000,000,000,000

Image compression

- Lossy compression - data is lost when the image is compressed
- Lossless compression - no data is lost when the image is compressed
- Image files can be compressed up to 20:1 without loss of data
- Compression of images saves storage space and also permits faster transmission of images

Copy images

- Convert to hard copy (film) - durable, expensive
- Paper copies - inexpensive, not durable
- CD-ROM or DVD
  - Can be viewed on any PC
  - The disk includes the application software for viewing (don’t need to purchase special software)

The Economics of PACS

- Higher fixed costs
  - Hardware, networking, storage media
- Lower variable costs
  - No film, no processor chemicals

Economics cont'd - Personnel

- Personnel costs with PACS
  - Fewer (if any) file room personnel
  - More information systems (IS) personnel
- Net result is break even or some increased cost with PACS

Economics cont'd - Space

- Decreased film storage space requirements
- Increased space for hardware
- Net result - large savings in space

Economics cont'd - Indirect costs

- Decreased time of exams
- Markedly decreased repeat exam rate
- 'No' lost films
- Decreased turnaround time
- More rapid decision making by clinicians

How many monitors are enough?

- Ohio State University, 3 hospitals and outpatient imaging facility
- 250,000 exams per year
- 26 radiologists and 10 experienced residents interviewed (54% had had experience with 4 monitor workstations)

Ref 25

How many monitors? Plain films

- 18 radiologists
  - 56% used 2 monitors
  - 44% used 1 monitor
- 10 residents
  - 80% used 2 monitors
  - 20% used 1 monitor

Ref 25

How many monitors? CT

- 24 radiologists
  - 17% used 1 monitor with 4 on 1 display
  - 8% used 2 monitors with 4 on 1 display
  - 54% used 1 on 1 ‘stack mode’ viewing
  - 21% used combinations of the above
- 10 residents
  - 100% used 1 on 1 ‘stack mode’ viewing

Ref 25

How many monitors? U/S

- 8 radiologists
  - 76% used 1 monitor with 4 or fewer images
  - 12% used 2 monitors
  - 12% used 1 on 1 ‘stack mode’ viewing
- 10 residents
  - 33% used 1 on 1 ‘stack mode’ viewing
  - 67% used 1 monitor with 4 or fewer images

Ref 25

How many monitors? MRI

- 19 radiologists
  - 37% viewed 4 separate sequences on 1 monitor
  - 71% used 2 monitors if more than 4 sequences in the study
  - 42% viewed each sequence 1 on 1 on 1 monitor
  - 5% viewed 2 series on 1 monitor
  - 15% used a combination

Ref 25

How many monitors? MRI cont'd

- 9 residents
  - 67% viewed 4 series on 1 monior
  - 20% viewed the study 1 on 1 on 1 monitor
  - 10% viewed 2 series on 1 monitor

Ref 25

How many monitors? Angio

- All viewed the studies 1 on 1. The second monitor was used for comparison studies.

Ref 25

How many monitors?

Before PACS

- 31% of radiologists felt that 2 monitors would be adequate
- 23% felt that 2 monitors would be needed for plain film imaging, but 4 monitors would be needed for cross sectional imaging
- 27% felt that 4 monitors would be needed for both
- 19% felt that more than 4 monitors would be needed

Ref 25

After PACS

- 88% felt that 2 monitors were enough for plain film images and cross sectional images
- 96% felt that fewer monitors were needed than they had previously thought
- 85% said that they preferred using 2 monitors rather than 4

Ref 25

Portability of images

- CD-ROM storage 640 Mb of data
  - 12 - 30 CT exams
  - 24 - 80 MRI exams
  - 60 - 128 ultrasound exams
  - 32 - 64 computed radiographic exams (‘plain film images’)
  - 80 digitized radiographs
  - 5 digitized mammograms

Ref 30

Cost of copies

- CD-ROM 2 to 4 dollars, stores numerous images
- Hard copy film 10 to 20 dollars per sheet (includes technical costs)

Ref 30

File Size of Exams

Exam	Dimension	Gray level	# images	Size
	(pixels)	(bits)		(Mbytes)
CT	512 x 512	12	70	36.7
MRI	256 x 256	12	150	19.7
U/S	512 x 512	8	30	7.8
CR	2,048 x 2,048	12	2	16.7
DR	2,048 x 2,048	12	2	16.7

Ref 30

Necessary to integrate PACS with the hospital information system, transcription and the electronic medical record in order to maximize efficiency.

Ref 31

Transmission speeds

Modality	Maximum bandwidth	Transmission speed for 1Mb	Transmission time for 80 Mb exam
Modem	56 kb/s	142.8 sec (2.4 min)	11,489 sec (190 min)
ISDN	128 kb/s	62.5 sec	5,000 sec (83.3 min)
DSL	384 kb/s	20.8 sec	1,667 sec (27.8 min)

Ref 32

Transmission speeds cont'd

Modality	Maximum bandwidth	Transmission speed for 1 Mb	Transmission speed for 80 Mb exam
Ethernet	10 Mb/s	0.8 sec	64 sec
Fast ethernet	100 Mb/s	0.08 sec	6.4 sec

Ref 32

Transmission speeds cont'd

Modality	Maximum bandwidth	Transmission speed for 1 Mb	Transmission speed for 80 Mb exam
Gigabit ethernet	1,000 Mb/s	0.008 sec	0.64 sec
ATM	155 Mb/s	0.52 sec	4.1 sec
Fast ether 10:1 comp	100 Mb/s	0.008 sec	0.64 sec

Ref 32

Security - 2 categories

- Access security - protection of computer systems against access by unauthorized persons
- Data security - protection of data transmission against electronic eavesdropping, content alteration or faking the identity of the sender

Ref 41

Conclusion

- PACS has revolutionized medical imaging.
- It involves new technology that must be learned and understood.
- At the present time it is the only way by which we can efficiently and effectively handle the vast quantities of imaging data that we are generating.

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