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Remote analysis of digitized x-ray image for bone injuries and other pathology

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- The purpose of the study was to evaluate the usfulness of new method (RODIA System) to monitor mineralization of the fracture gap on digitalized x-ray, osteolysis or loosening around orthopedic implants or other bone pathology.

- Collection of radiographs of various orthopedic pathologies was digitized for further analysis.

- Image Evaluation Module and Fracture Healing Monitor Modules of Relative Optical Density Image Analysis (RODIA) System were utilized for images evaluation.

Problem

Methods allowing quantitative evaluation are required for Evidence Based Medicine and statistical evaluation of collected data for specialties largely utilizing images

(i.e. orthopedics and orthopedic trauma)

Requirements

Valuable method should:

- predict end point of fracture healing
- point out suitable time for hardware removal
- determine affeted extremity loading possibilities
- predict early healing disturbancies
- allow to evaluate various factors influence on fracture healing
- allow statistical analysis
- allow to create models of fracture healing
- collect clinical and scientific data

Available quantitative methods

- Clinical scaling – surgeons hands
- Biomechanical (strain test –applicable for particular locations)
- Radiologic - (expert's evaluation) – scaling (pts)
- Acustic & vibratonal (i.e. Ultrasonometry)
- DEXA scanning – no software available
- ***Relative Optical Digital Image Analysis – with or without digital radiography (RODIA, RODIA for DXA scan)***
- Computed Tomography including quantitative evaluation (CT, QCT, pQCT)
- Magnetic resonance imaging (possible for no hardware)

Densitometric evaluation of X-ray

Laser densitometry – early study

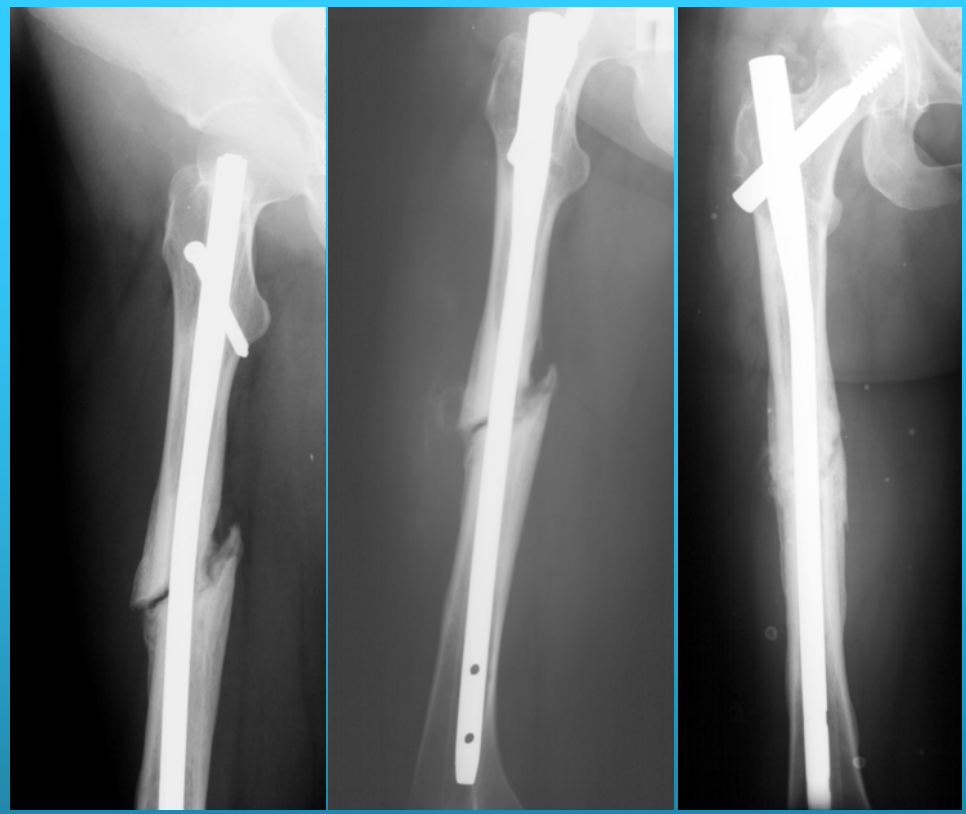
laser
densitometer

UltroScan XL
Pharmacia LKB

Pseudo 3 D visualisation plot

- **ImagePro+ 4.1 (Media Cybernetics) function "Surface Plot".**

Female M.L. 28

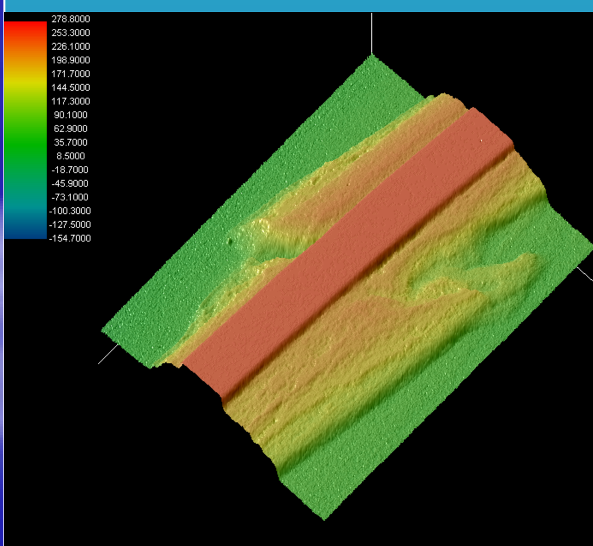


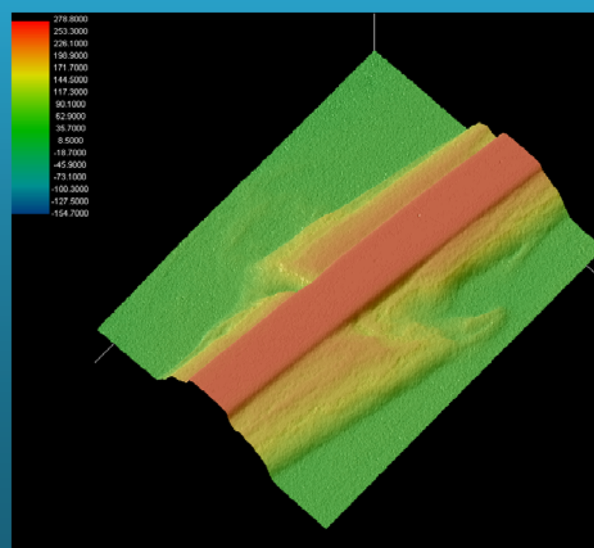
- Fracture 09. 2000
- IM nailing elsewhere
- No healing till 2002
- One month after BMP -7 implantation
- 8 weeks after implantation

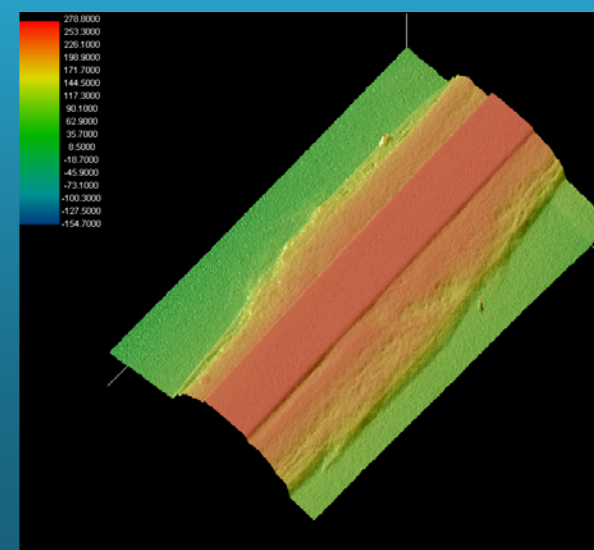
Female M.L. 28

Pseudo 3D computer enhanced healing progress evaluation

(Image Pro+)







Pseudo 3D Visualization of X-ray Image in Medical Diagnostics

Introduction

In spite of technological progress in medical imaging classical X-ray **is still a prima**

Differentiation of pixel

be recognized as a su

molecules. Therefore

cross-sections of invest

some information abo

recover this informatio

be defined **as pseudo 3**

Pseudo 3D Visualization of X-ray Image in Medical Diagnostics

Methodology

The simplest

For image digitized u

The matrix of optical

by integers stored int

Then the matrix con

of pixels. **The ODV**

Two other dimension

Rodia - version B.1

VIEWTABLE: work.at

	MY	X430	X431	X432	X433	X434	X435	X436	X437	X438	X439
1	0	166	169	166	170	168	170	169	169	176	179
2	1	167	166	167	169	169	173	170	170	174	176
3	2	169	166	171	168	170	172	171	172	173	174
4	3	172	169	170	167	169	168	170	172	172	174
5	4	172	173	169	167	172	167	170	172	172	175
6	5	170	172	172	169	171	168	170	172	175	176
7	6	168	168	172	170	170	169	171	170	175	171
8	7	169	169	167	171	170	175	172	170	169	168
9	8	171	172	170	176	174	176	175	173	169	170
10	9	169	172	173	176	175	172	176	173	175	176
11	10	170	173	174	172	176	176	179	179	181	179
12	11	173	171	176	173	176	179	181	181	181	180
13	12	174	170	176	177	178	178	182	177	182	180
14	13	174	176	172	176	175	179	179	179	182	177
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26	25	177	178	179	176	181	183	184	184	184	182
27	26	175	178	177	176	178	178	178	179	181	179
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29	28	177	174	176	174	175	176	179	181	181	184
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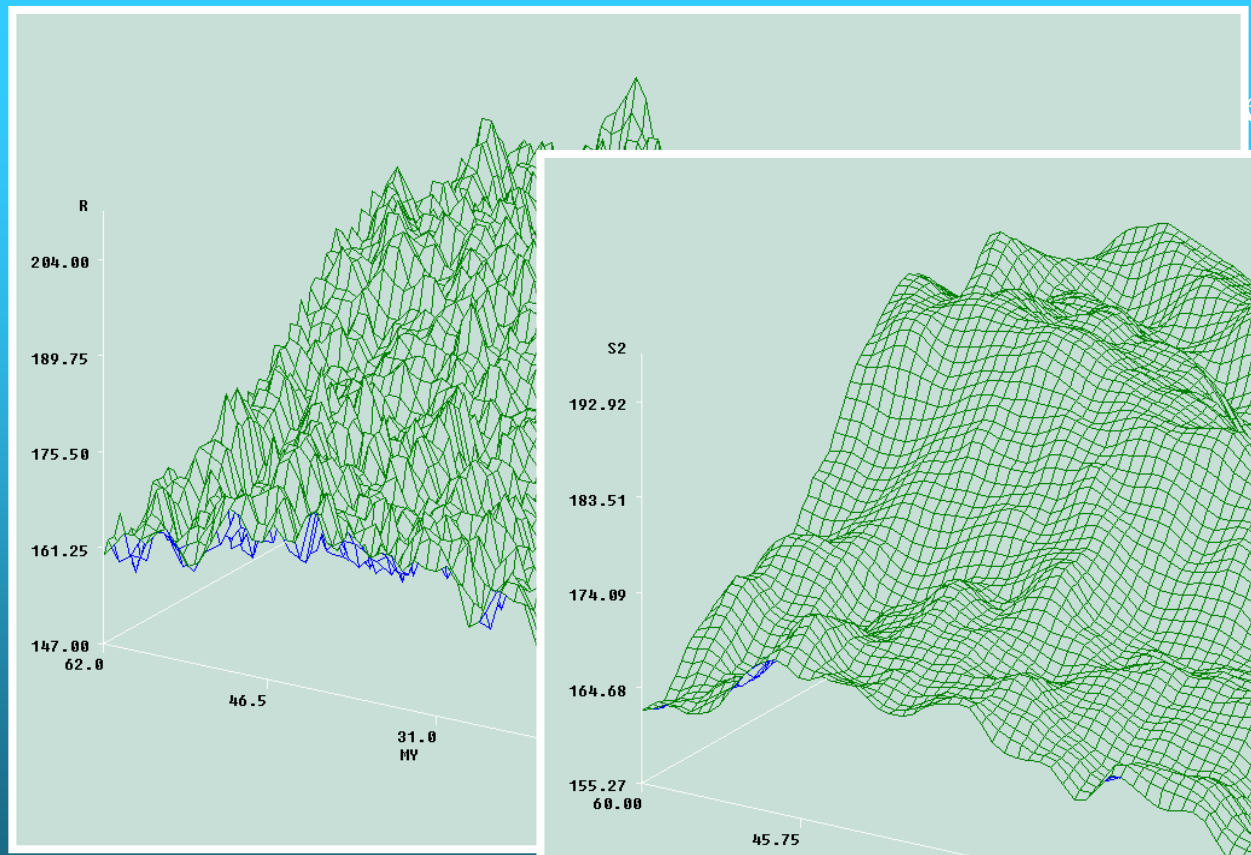
31	30	174	173	178	177	182	180	182	180	182	182
32	31	172	174	174	177	182	180	182	180	183	181
33	32	172	174	175	177	177	180	177	176	181	178
34	33	173	175	179	179	175	177	175	175	178	176

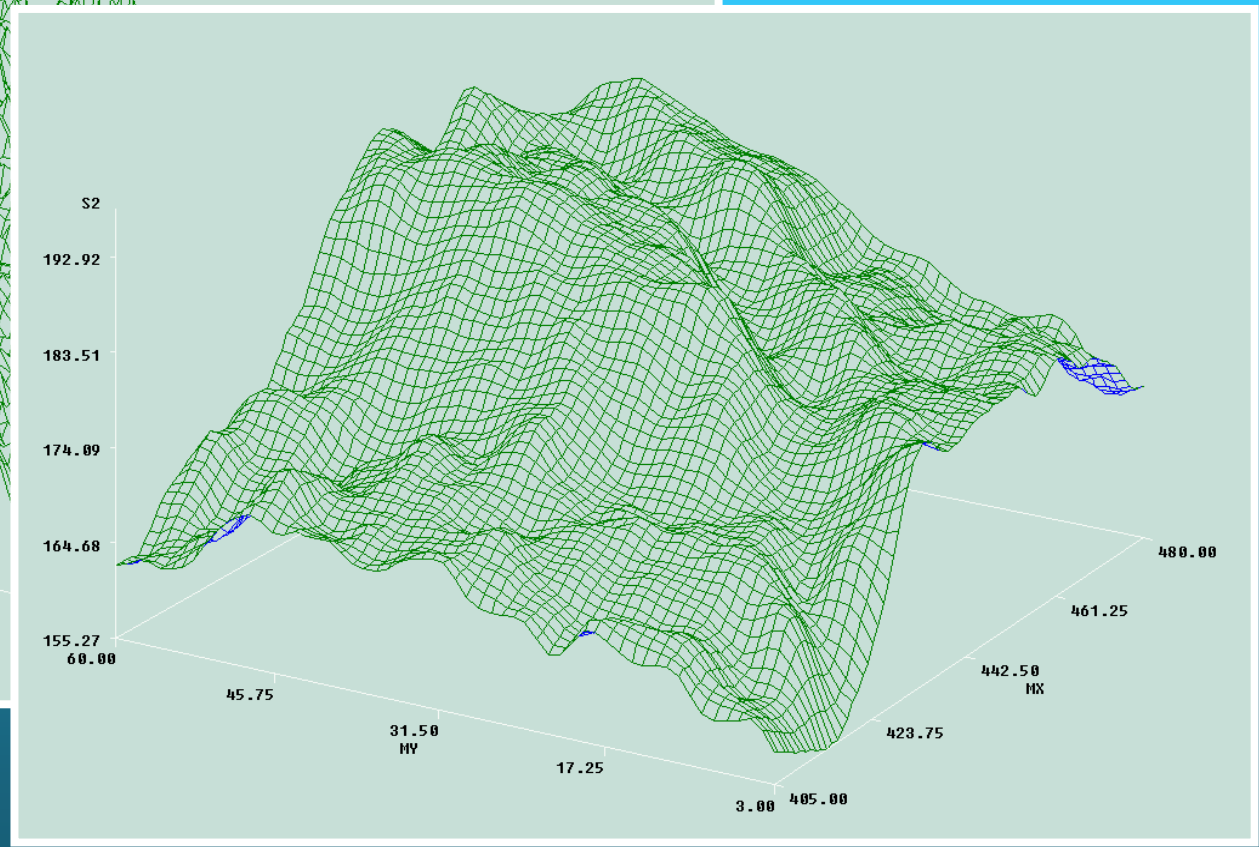
NOTE: Table has been opened in browse mode.

Pseudo 3D Visualization of X-ray Image in Medical Diagnostics

Methodology

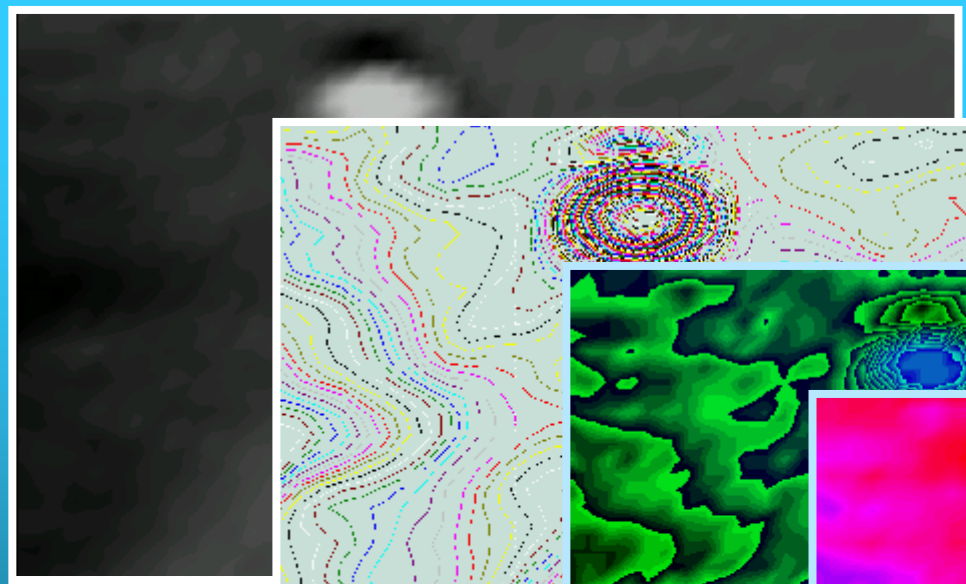
e contour lines joining





Pseudo 3D Visualization of X-ray Image in Medical Diagnostics

Methodology



P3D visualization and **cannot**

must be constructed

make or c

Simplicity is a strong

Pseudo 3D Visualization of X-ray Image in Medical Diagnostics

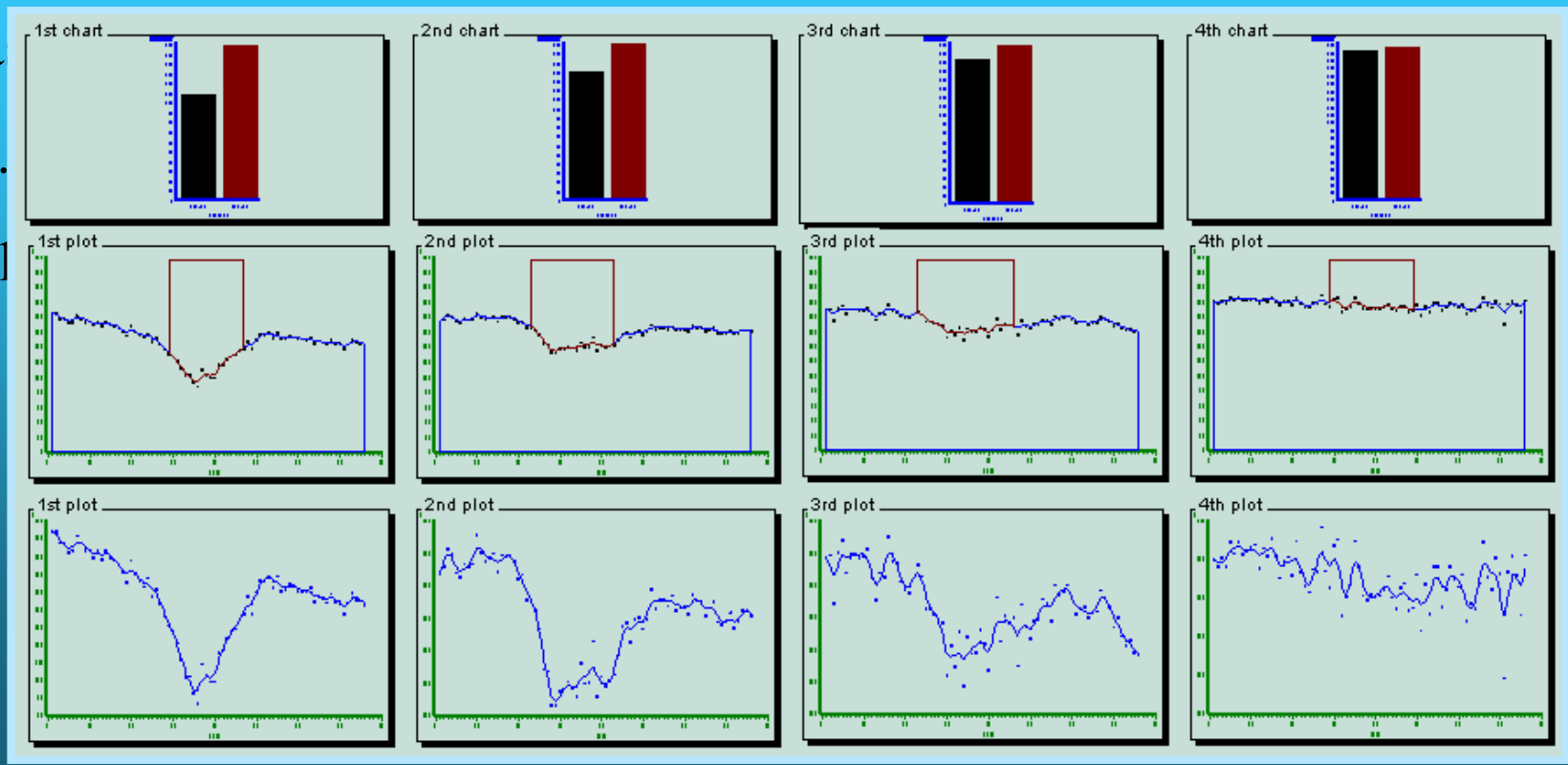
Other Methods

Optical Density Matrix is **good starting point for** quantitative

mea

(e.g.

impl



Methods enhancing diagnostic imaging

Methods incorporated to RODIA System®.

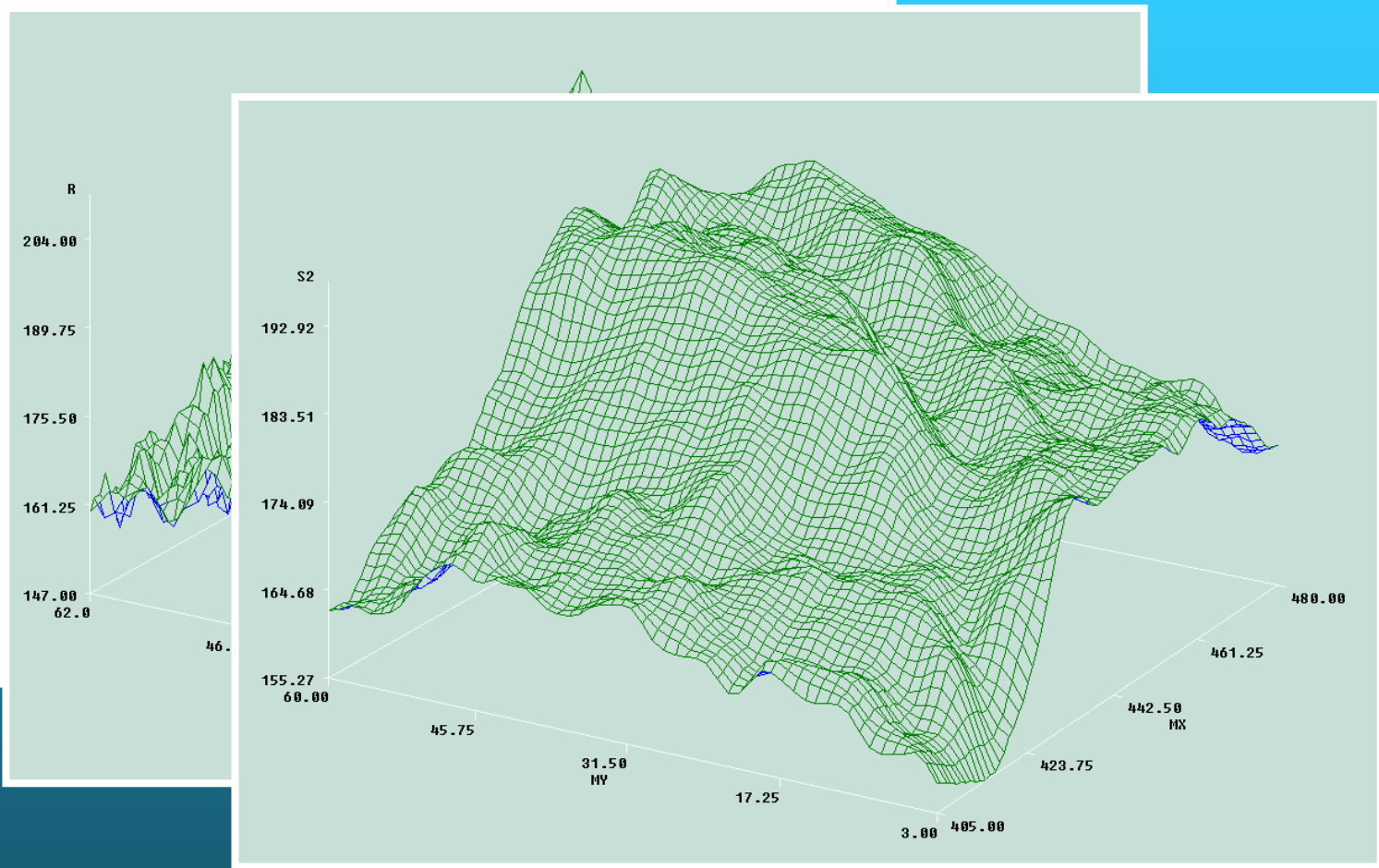
- Data conversion: image -> matrix 2D
- Quantitative monitoring of fracture healing
- Plot of structure of isodensity lines
- Enlargement, GS to HLS exchange
- P3D interpretation
- P3D noise filtration
- Three dimensional viewing of P3D graphics
- Pattern identification
- Calibrtion, ¸linear and angular measurements

- Telemedicine friendly

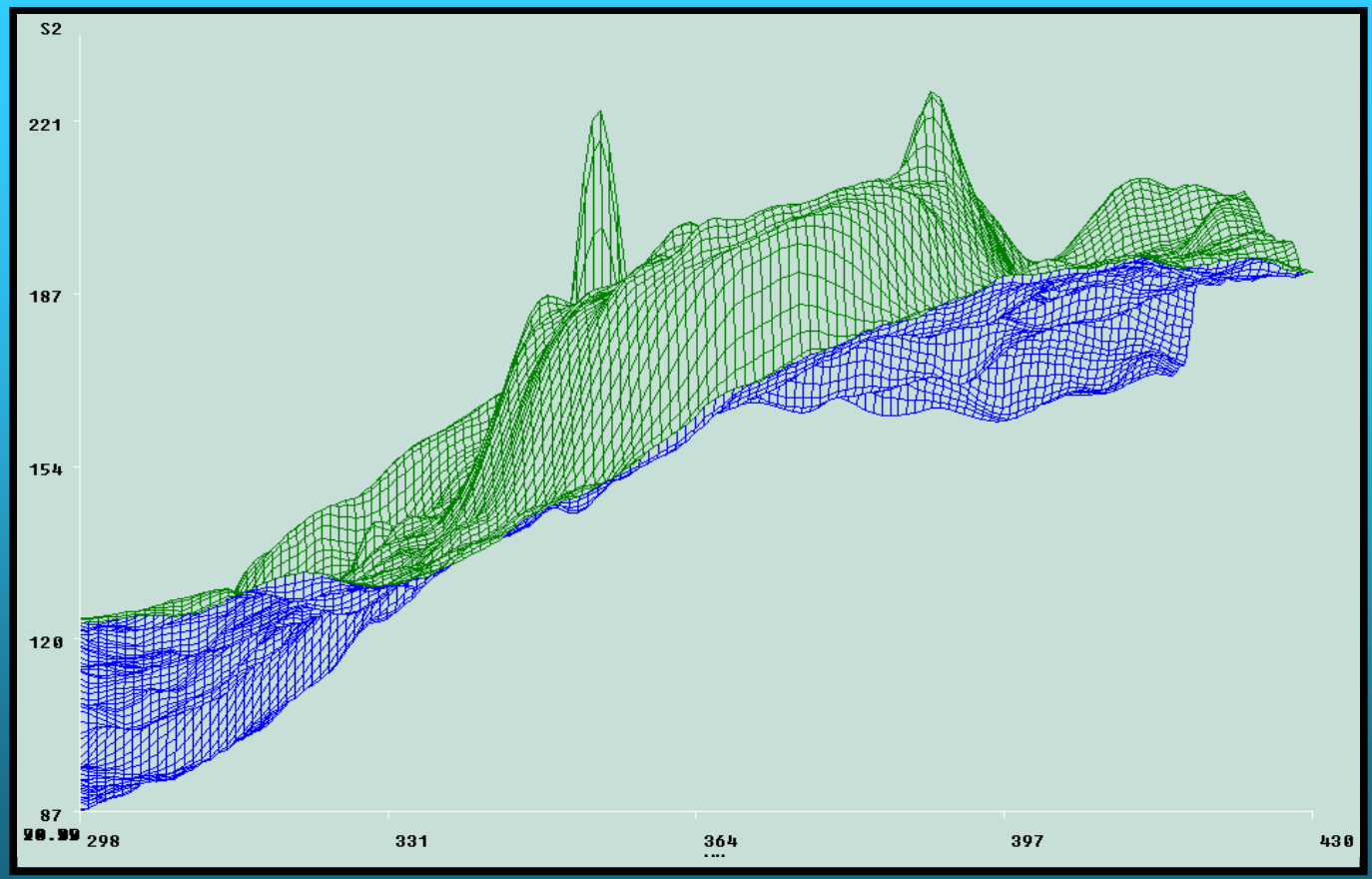
Methods enhancing diagnostic imaging

P3D noise filtration for searching fracture line

4th

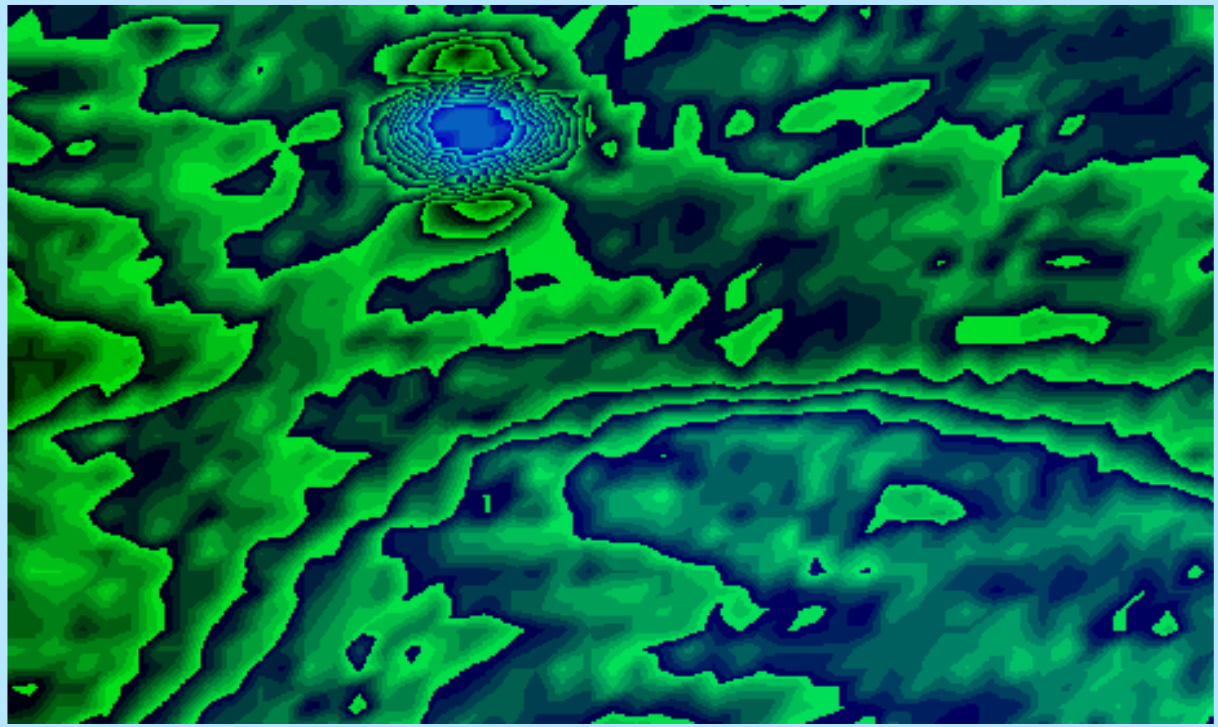


Graphics rotation P3D



Pattern identification

1. GS enlargement
2. Stratal identification
3. HLS conversion
4. Pattern enhanced exposure of „quantum” ODV changes



Calibration and linear measure

Calibration:

- To allow comparison of consecutive X-rays despite of scale or 3D rotation differences

Linear measurements:

- Direct accordingly to known object seen on image (size phantom)
- Indirect (%)
- Area
- Avg ODV of various ROI's
- Angular

Methods enhancing diagnostic imaging

Approach to data aquired from image - RODIA System®.

Nonrelative (direct):

- Standardization necassary
- Phantom calibration
- High quality requirements

= calibrated results, values (g/cm^2 or g/cm^3)

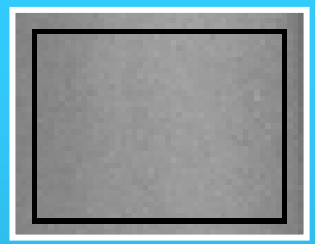
Relative:

- Entire image calibration
- Extremely lower quality requirements
- Minimal preparation

= calibrated results, values compartatively expressed (%), sufficient for monitoring

Methods enhancing diagnostic imaging

FHM module of RODIA System®.

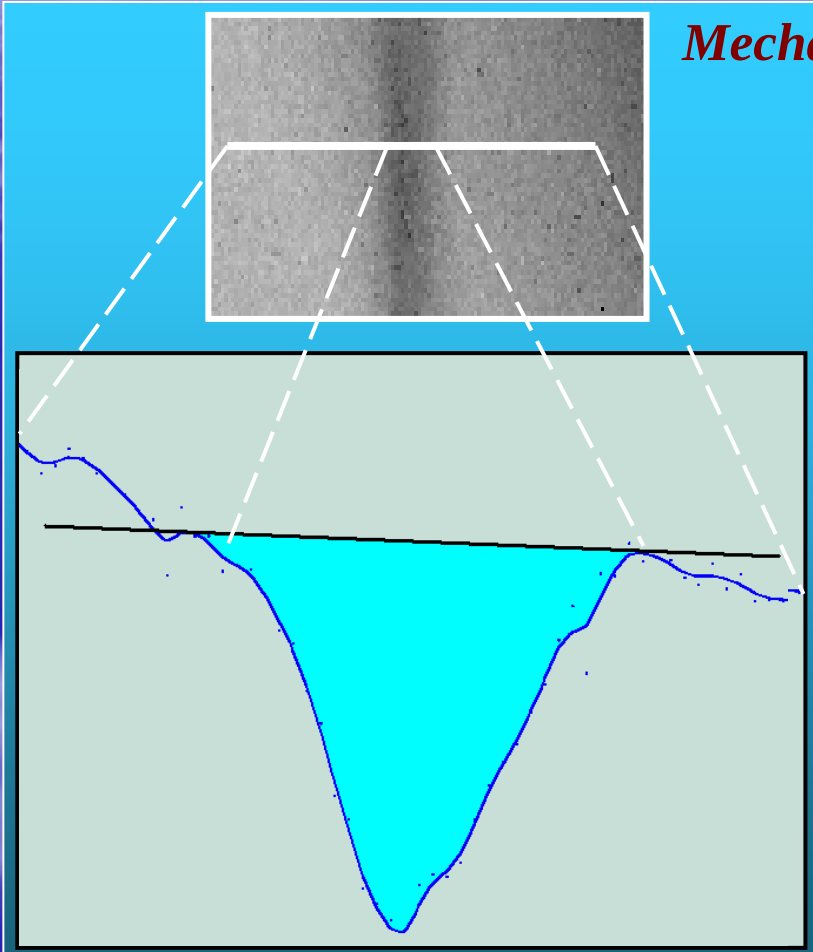


1. Data aquisition
2. Choice of ROI
3. Excision
4. Enlargement

ROI Fragment of X-ray
Ready for further analysis

Methods enhancing diagnostic imaging

FHM module of RODIA System®



Mechanism of fracture gap ODV measurement

Steps of analysis:

1. Choice of gap across ROI
2. Pseudo cut along *h value*
3. Pointing gap's edges
4. Calculation of gap's volume

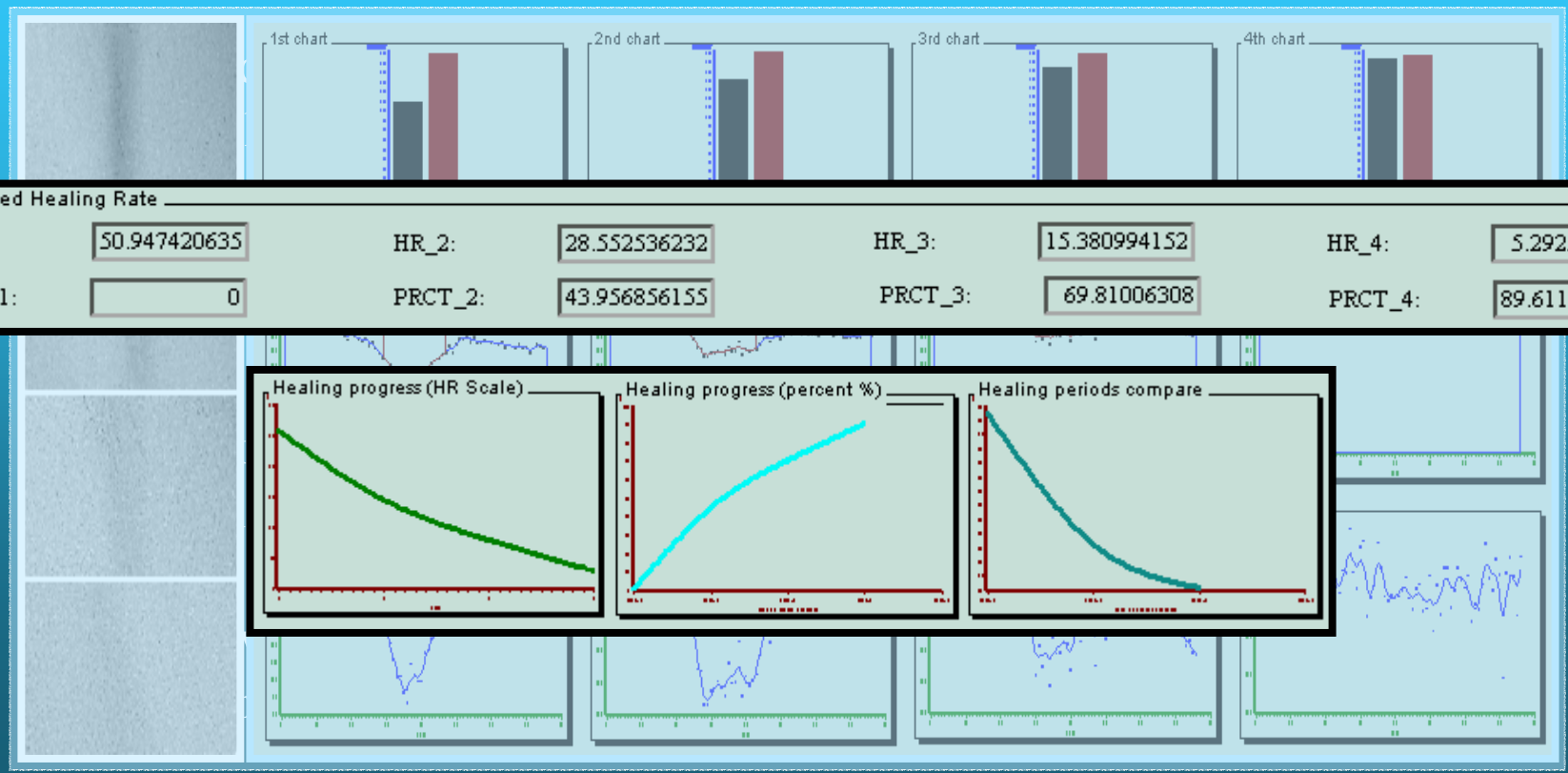
5. Repetition of 1-4 along gap on ROI

gap's volume calculated as integral

Methods enhancing diagnostic imaging

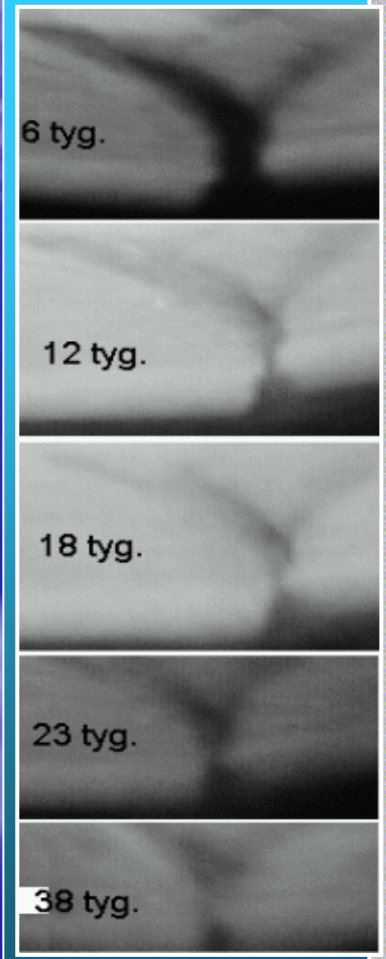
FHM module of RODIA System®

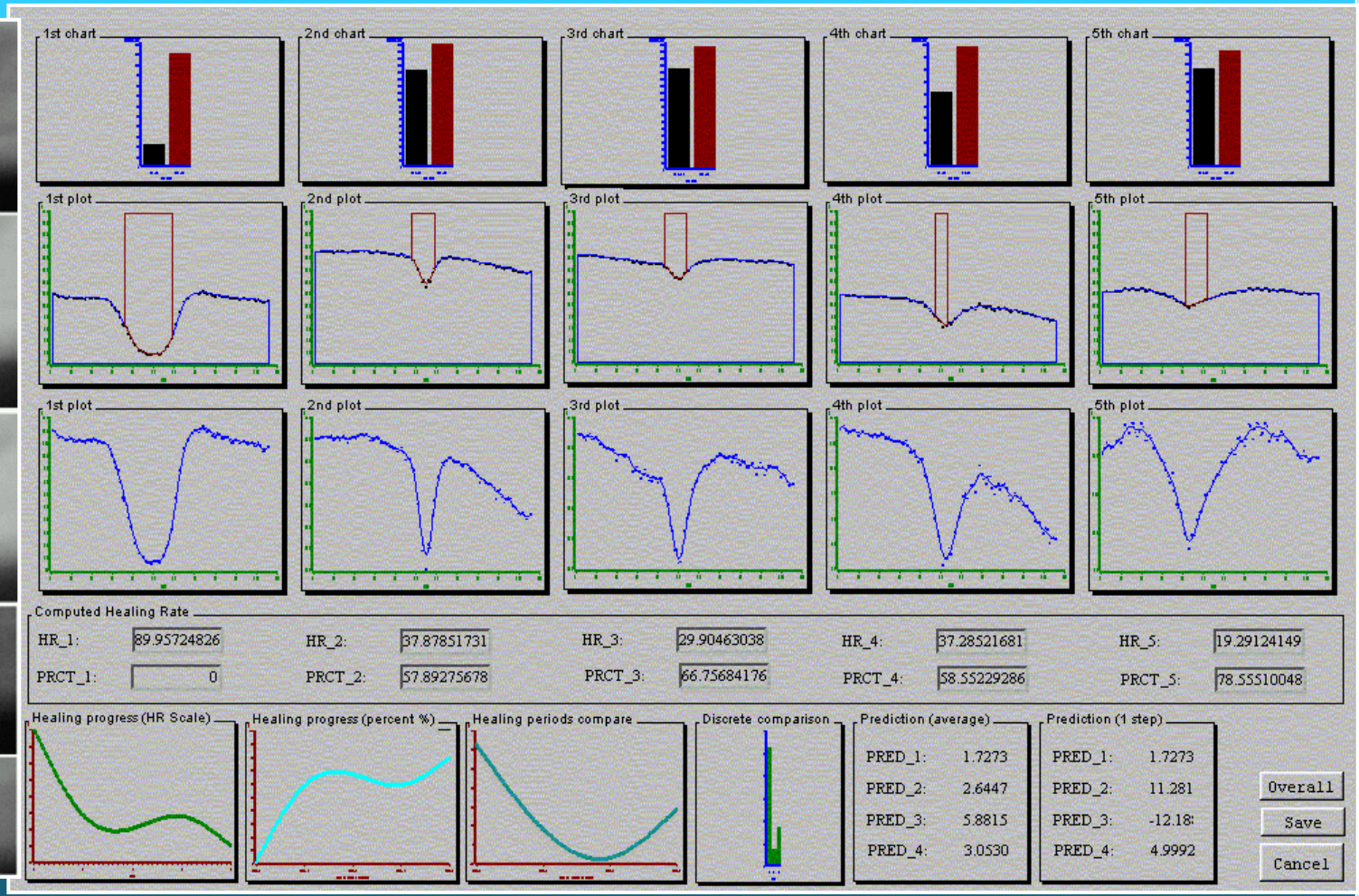
Monitoring of tibial fracture based on x-ray follow –up
(4 weeks periods)



Methods enhancing diagnostic imaging

FHM module of RODIA System®



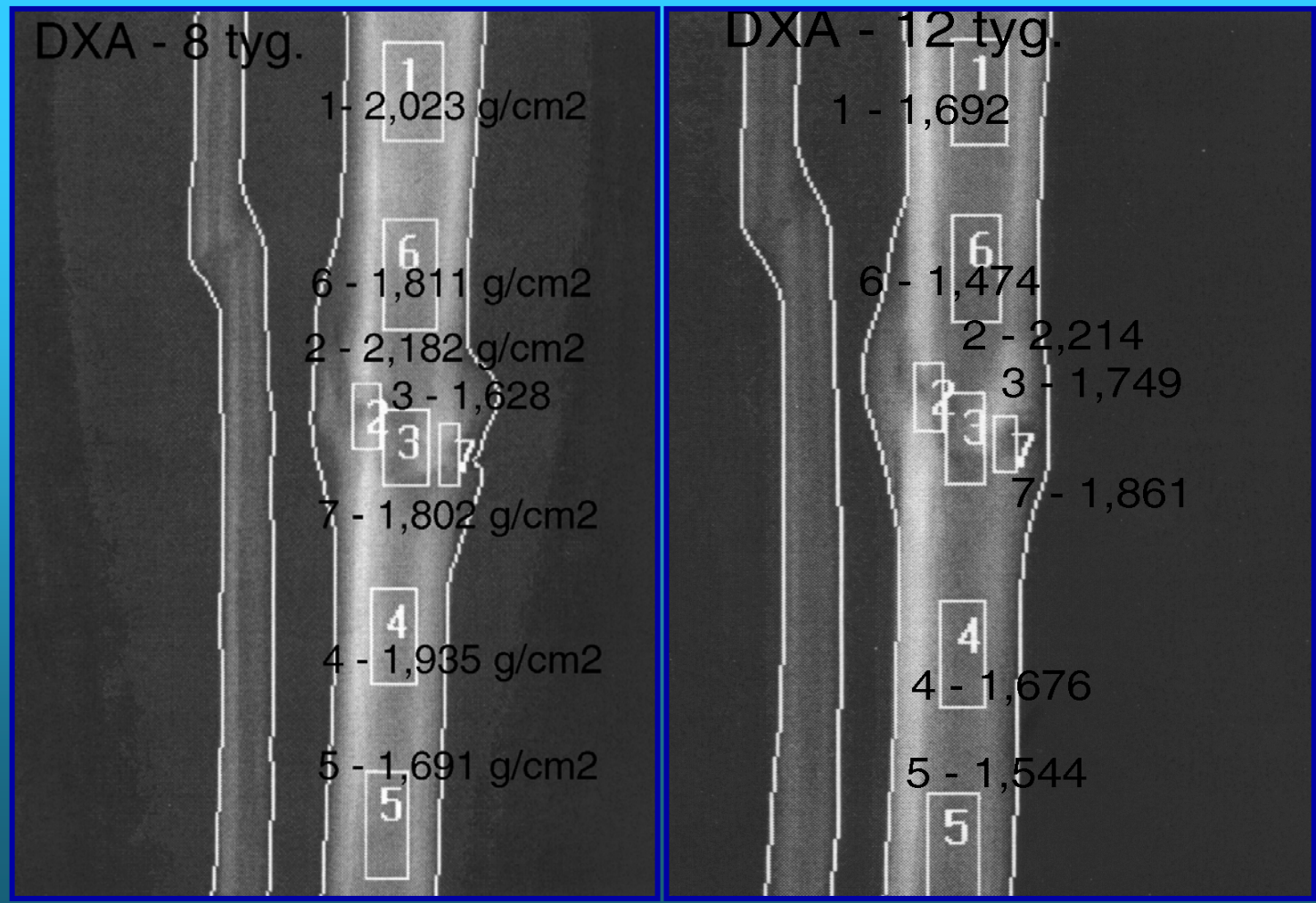


Methods enhancing diagnostic imaging

FHM module of RODIA System® - Applied to DXA scan image

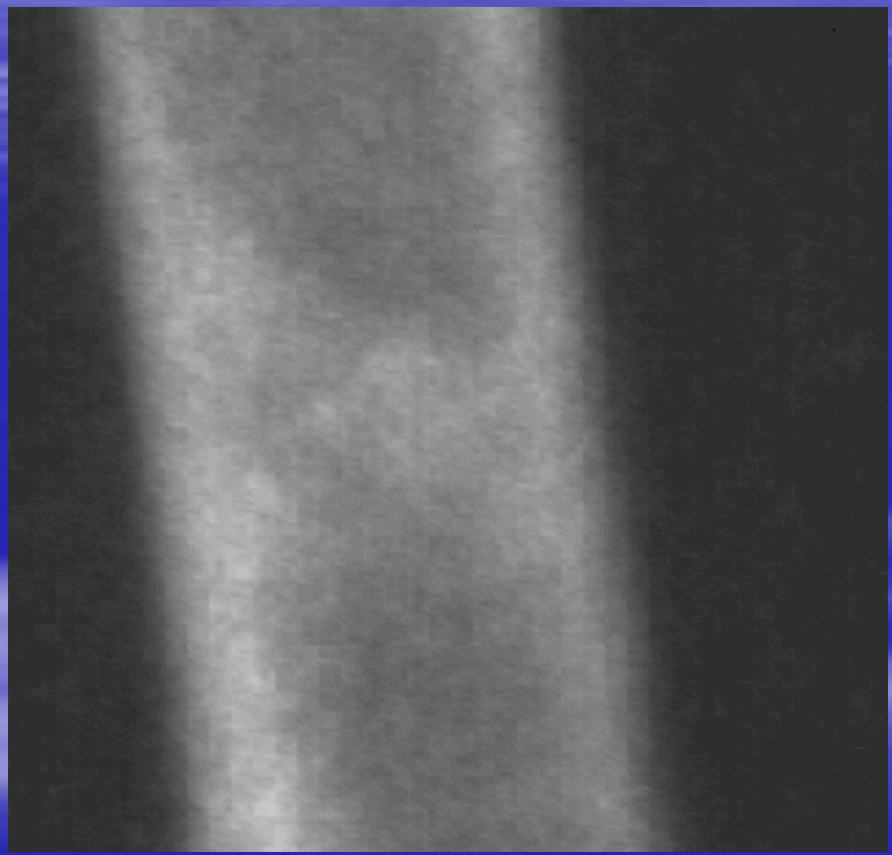
Methods enhancing diagnostic imaging

DXA scan image custom analysis for fracture case

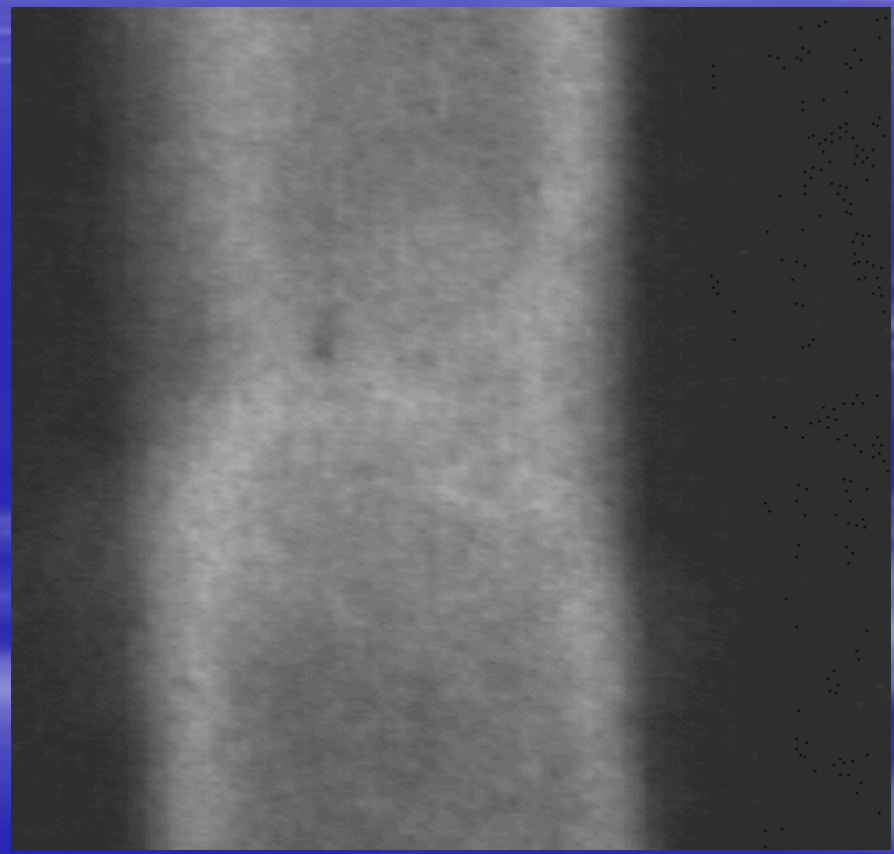


RODIA System
Experimental research application

Digitized classic X-ray images of rats femora

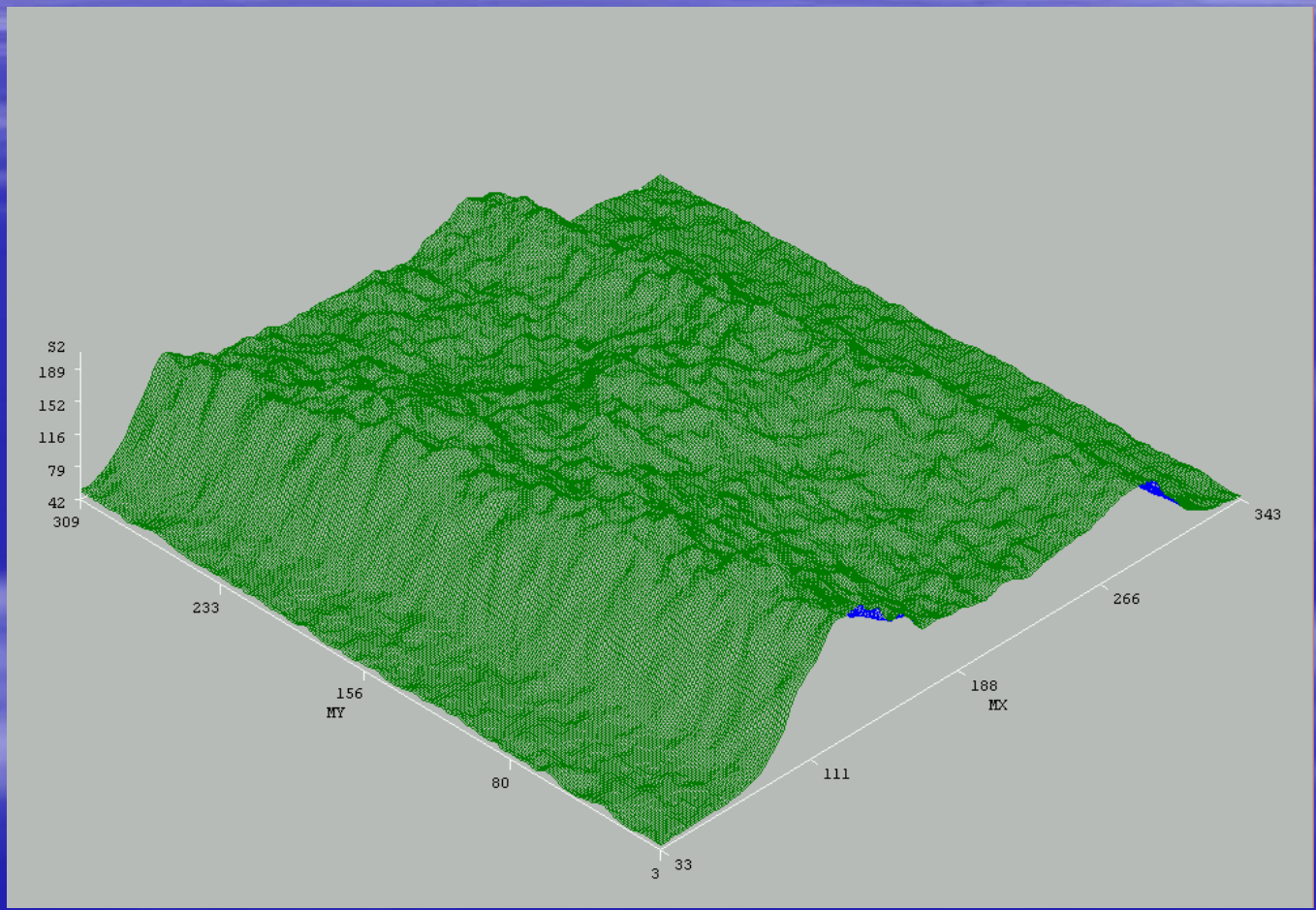


Right - Laser irradiated

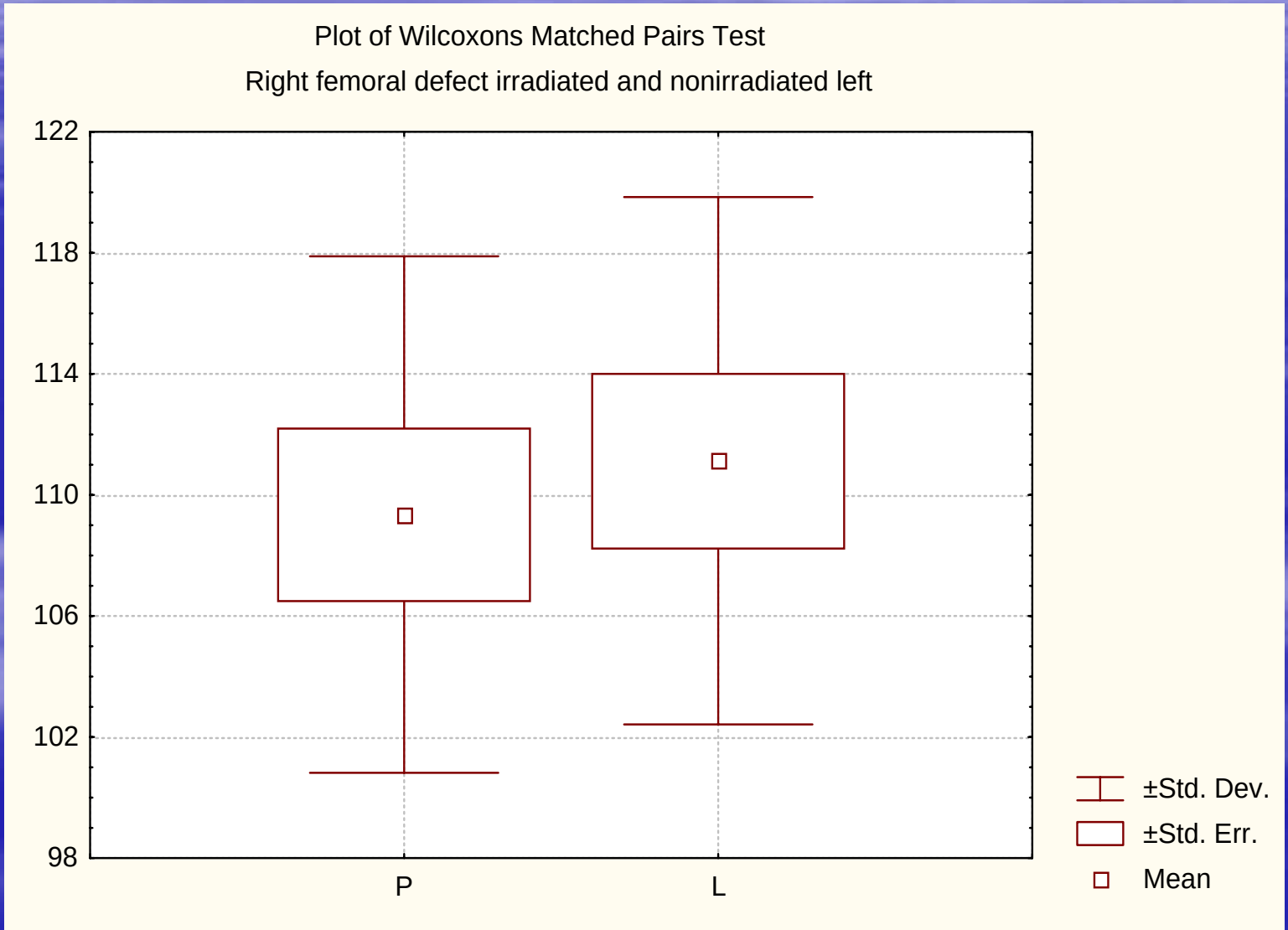


Left control

RODIA System - Pseudo 3-D evaluation



Measured optical density values available for statistical analysis



- Search for subtle fracture line, assessment of the bone osteolysis around orthopedic implants, and progress of bone tumour retrospective avaluation were performed with RODIA System. Developed Relative Optical Density Image Analysis System (RODIA System) allows remote analyzing and measure digitized X-ray image to reliably enhance of image evaluation.
- Reference
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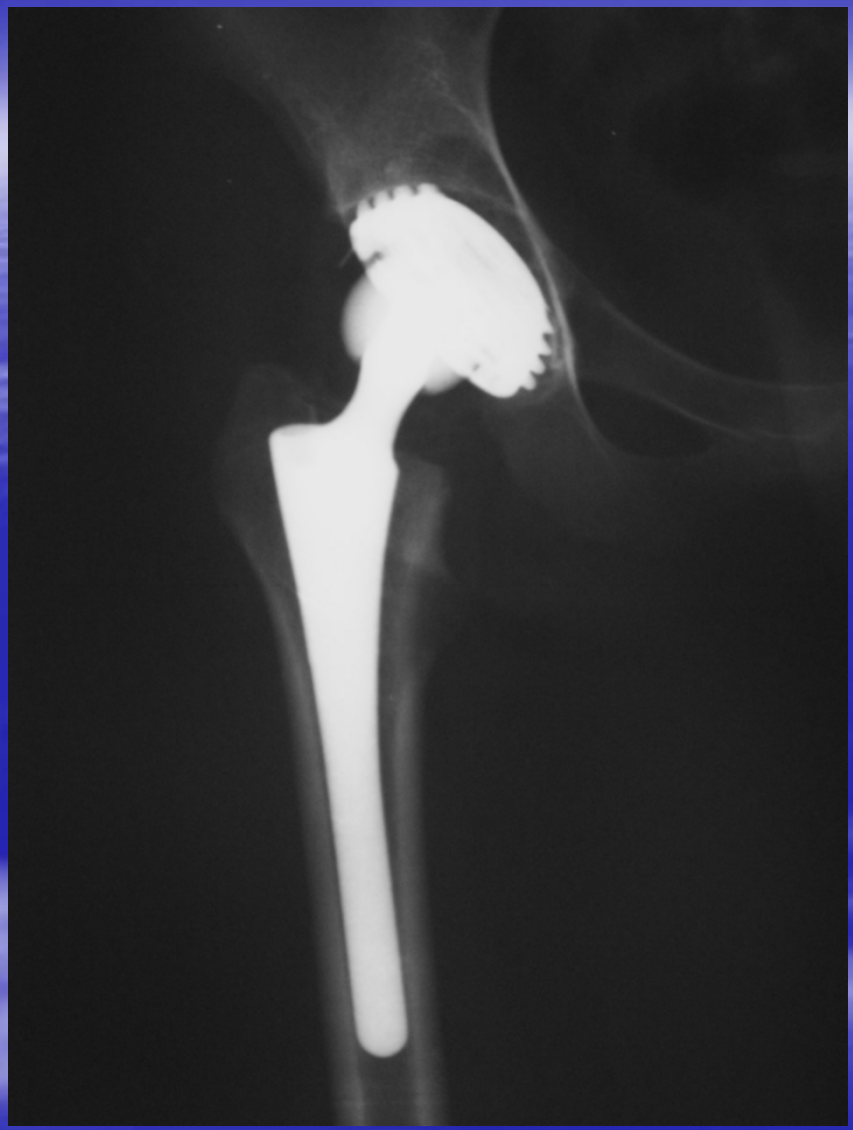
3 months after surgery



12 months after surgery

Periprosthetic Optical image density evaluation
accordingly to zones described by Gruen
(Relative measure and monitoring)
Medial proximal femur resorption noted

Methods enhancing diagnostic imaging

RODIA System ®

bas

It

onl

De

Relative Optical Dens

Analysed Picture

Calibration

1st point

2nd p

About RODIA System

RODIA System

for Medical Imaging Purposes

Fracture Healing Monitor
Image Enhancer
Image Enlarger
Noice Reductor
OD Meter
P3D Visualiser
Region Calibrator

RODIA System
version Beta (1)
Copyright Malsh Software 1997-1998

Programming: Maciek Kornacki
Consultations: Marek Karwański, Adam Bartos, Wojciech Glinkowski

with cooperation of SAS Institute POLAND, Praski Hospital
and Warsaw University Faculty of Biology

This program cannot be used for any commercial purposes
and cannot be duplicated.

OK

About

Stop:
559,393

HLS & Gray
repeat: 100

Gray
iterat: 200

Grid options
naxis1: 500
naxis2: 500
Interpolation:
join

Contrast
256 GScale

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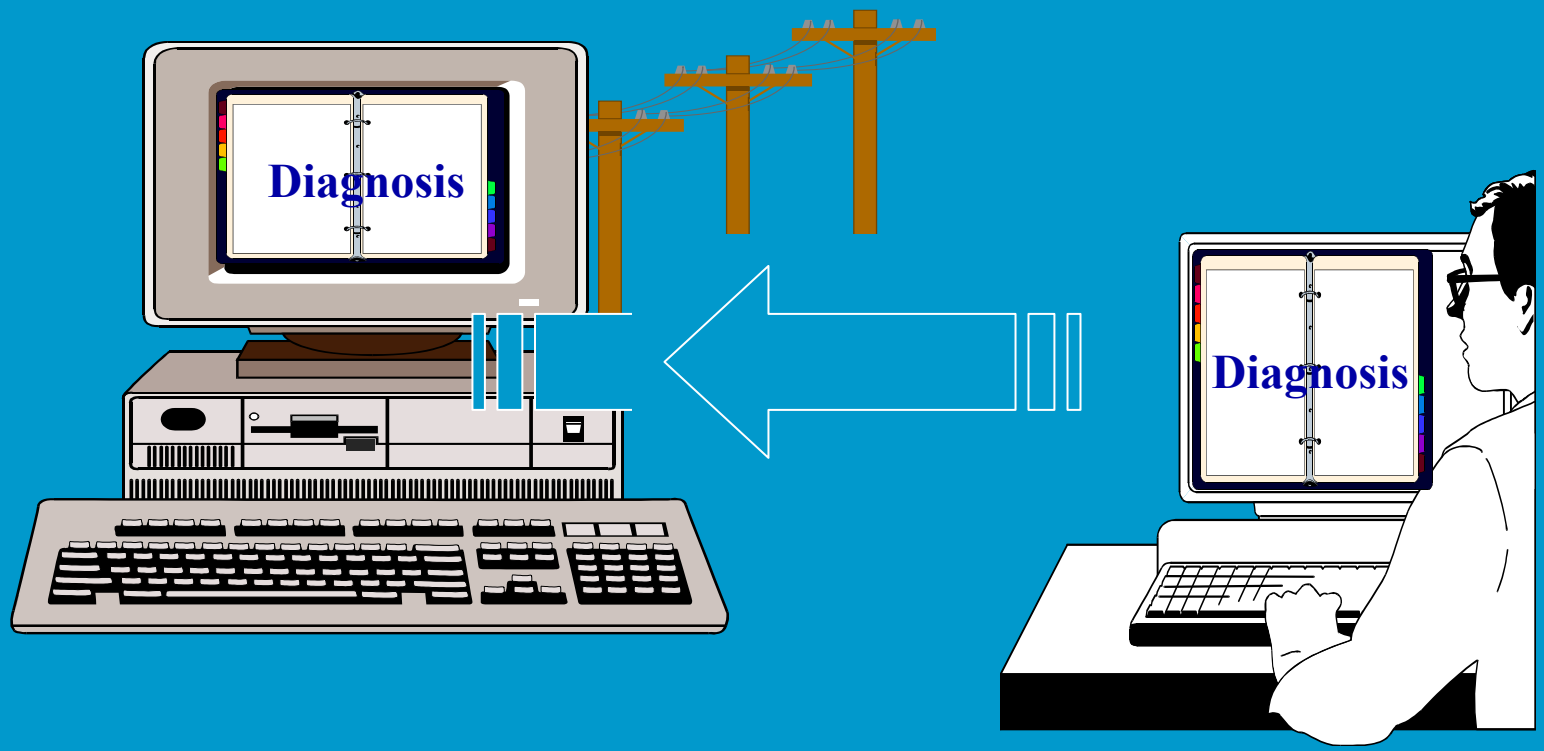
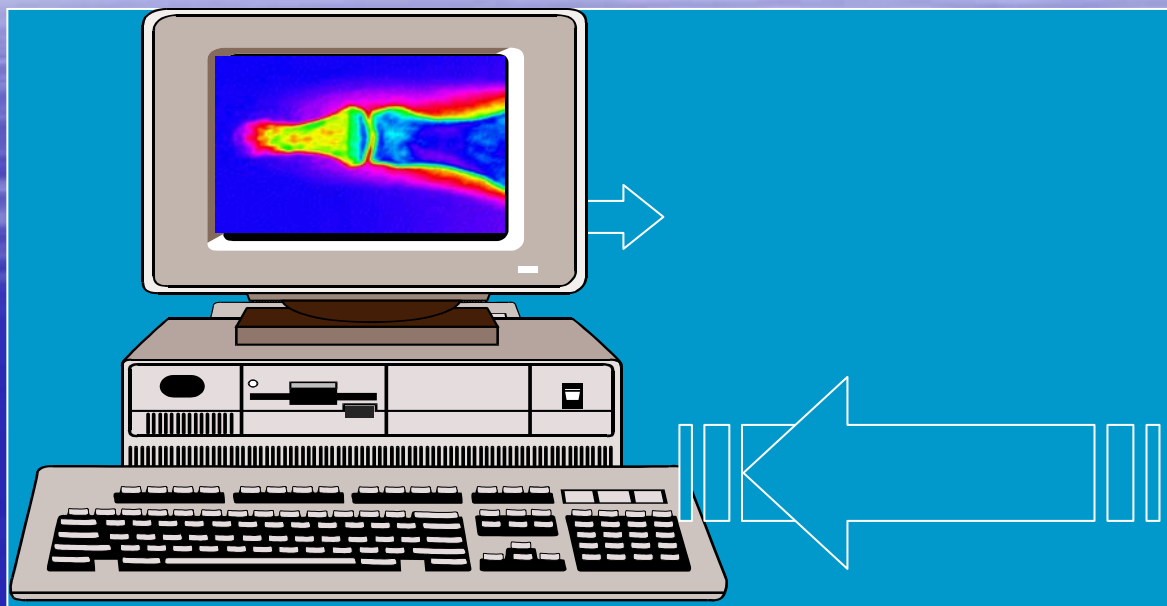
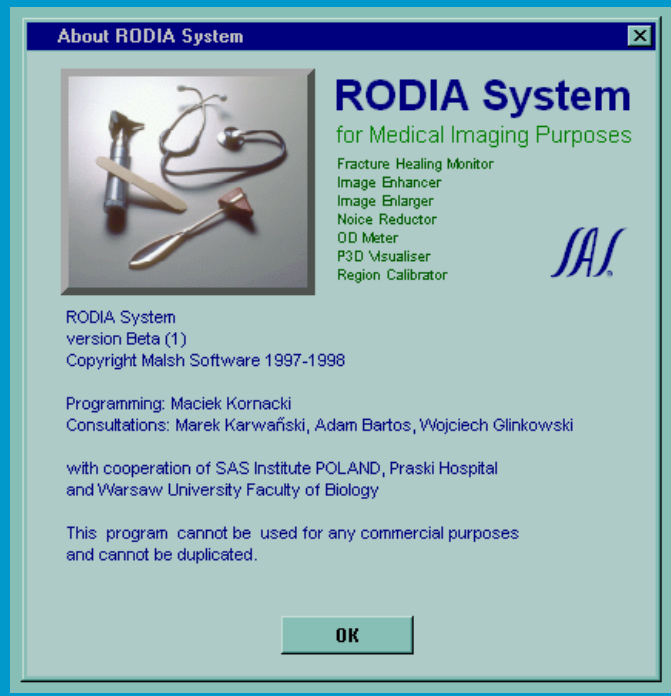
m ®

Classic teleconsultation

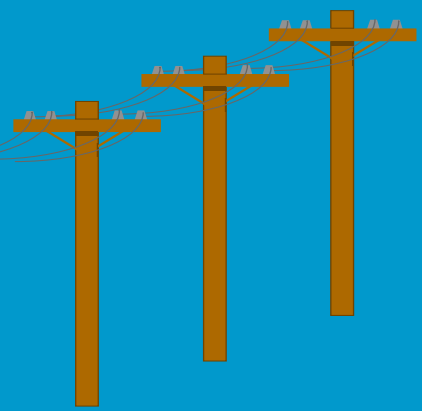


Future Prospect - TeleRODIA





For physician
TeleRODIA may allow to operate from his own PC,



(Lower expenses of
High Level PC)

R O D I A - Methods enhancing diagnostic imaging

RODIA System ® - spectrum of applications

Orthopedics:

- fracture healing monitoring
- bone remodeling monitoring
- detection of „hair line" fractures

Orthopedic oncology:

- early detection of bone tumours
- tumor size measurements
- image homogenity evaluation
- monitoring of tumor image changes in time

•Radiology:

- evaluation enhancement, image enlargement, etc.

Telemedicine

- remote diagnosing and monitoring

Conclusions

Development of modern analytic tools may lead to improvement of further rationalization of medical treatment i.e. orthopedics.

Developed methods may enhance global and individual interpretation of results their monitoring and more detailed searching for factors influencing on outcomes.

Development of analytic tools may affect :

- **prognosis, early prediction of disturbancies, effectivness of treatment**
- **scientific verification of results as seen on images**
- **statistical analysis and modeling**
- **documentation**

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Thank you for your kind attention