ADC COMPACT
FULL-LEG/FULL-SPINE
APPLICATION SOFTWARE

USER MANUAL

TABLE OF CONTENTS

Full-leg/full-spine image stitching: a new and accurate CR-based imaging software

The conventional approach

Full-leg and full-spine radiological examinations require a larger portion of the body to be imaged than can be fitted onto even the largest single imaging cassette. Conventional screen/film radiography has evolved methods for dealing with this problem. When the sub-images generated on separate films are put together, grid lines are used to ensure that they are correctly aligned. However, the overall process is exacting and not always completely accurate.

CR and the automation of full-body imaging

The process for obtaining a full-leg/full-spine image using the ADC Compact system is similar to the method used in conventional radiography, except that the screen/film system is obviously replaced with phosphor plates. During exposure an attenuating grid is present in the path of the X-ray beam, which leaves the imprint of a regular framework of thin parallel horizontal and vertical lines on the images.

But once the images have reached the workstation, they cannot easily be brought into perfect alignment, as the degree of distortion is not qualified or quantified. The ADC Compact Full-Leg/Full-Spine Application Software automates the process of forming a geometrically accurate full-body image, with as little user interaction as possible. There are several sources of ***misalignment*** or "***skew***", any or all of which may be present:

- ***overlap***
  Typically, four 24 x 30 cm plates are arranged in a 30 x 90 cm cassette for a full-spine exam, and three 35 x 43 cm plates are arranged in a 35 x 105 cm cassette for a full-leg exam. Where the plates overlap, the image will be normally exposed for the plate lying on top, and less exposed for the plate underneath.

- ***shift***
  The displacement of an image in a direction perpendicular to the body axis.

- ***rotation***
  Image rotation is caused by a slight rotation of the imaging plate in the cassette.

- ***interline distance foreshortening***
  in vertical and/or horizontal direction is caused by a slight tilt in the plates from the vertical or horizontal plane.

  The digital image-processing algorithm of the ADC Compact Full-Leg/Full-Spine Application Software has been designed to correct all of these distortions simultaneously, and to assemble one composite image showing geometric continuity of body parts. This is the technique known as "***image stitching***", as the anatomic entities crossing image borders are re-arranged in an uninterrupted and seamless way.

Steps in the image-stitching algorithm

What are the key elements of the image-stitching algorithm used in the ADC Compact Full-Leg/Full-Spine Application Software? First, the sub-images are input into the user interface of the ADC Compact Interactive Processing software, where the operator indicates the order of the constituent images and rotates them where necessary, so that all body parts are in the upright position.

From here, the stitching process proceeds automatically. The grid lines are now extracted from each image and stored in analytical form. In the grid calibration step, horizontal and vertical periodicity vectors are extracted and new “target” coordinate positions of all grid lines in each sub-image determined. A “de-skewing” operation follows, in which firstly the vertical grid lines and secondly the horizontal grid lines are shifted to their associated perfect target positions. Linear interpolation determines how much each pixel in the target image should be adjusted.

A further interpolation process is now needed to resample the input image. The method selected for this (known as the “cubic B-spline interpolating kernel”) computes the target pixel’s value from the input image pixels in such a way as to maintain maximum image resolution.

The result of this process is an image with equidistant and perfectly horizontal/vertical grid lines. It now remains to correct the overlap between successive images. After this has been done, the image-stitching module finally builds a composite total body image from the adjusted sub-images, omitting any overlap regions.

Clinical advantages of the full-body imaging technique

Orthopedic diagnosis will benefit from this new and innovative application software in areas such as the assessment of scoleosis. Potential applications include, for example: accurate measurement of spine angles and distances between anatomic entities, assessment of the evolution of therapy over time, identification of orthopedic surgery indications. Others will no doubt emerge during routine use of the software package.

Full-Leg/Full-Spine Stitching : how to proceed?

Introduction

As explained above, full-spine and full-leg examinations require the use of several overlapping plates in a single cassette or the use of several ADC Compact cassettes in a specially-built cassette-holder. The sub-images that are created are then combined into a single image with the help of attenuating grid lines to ensure accurate alignment during exposure. The ADC Compact Full-Leg/Full-Spine Application Software compensates for the various sources of misalignment referred to above, like overlap, shift, rotation and perspective foreshortening. The complete procedure is as follows.

Performing the examination

The ADC Compact Full-Leg/Full-Spine Application Software requires the use of a special Planfeld grid during exposure. The minimal line distance of this grid must be more than 30 mm and the maximum line distance must be less than 70 mm. Currently there are two different methods for performing the exposure:

- Several plates in a full-leg/full-spine cassette
- Several ADC cassettes in a specially designed cassette-holder.

The ensuing image composition or stitching process is identical whichever exposure method is used.

Method 1 : several plates in a full-leg/full-spine cassette

Plate and cassette selection

Select the size of plate and cassette you are going to use.
Typically, this will be :

- Four 24 x 30 cm plates with a 30 x 90 cm cassette for a full-spine examination.

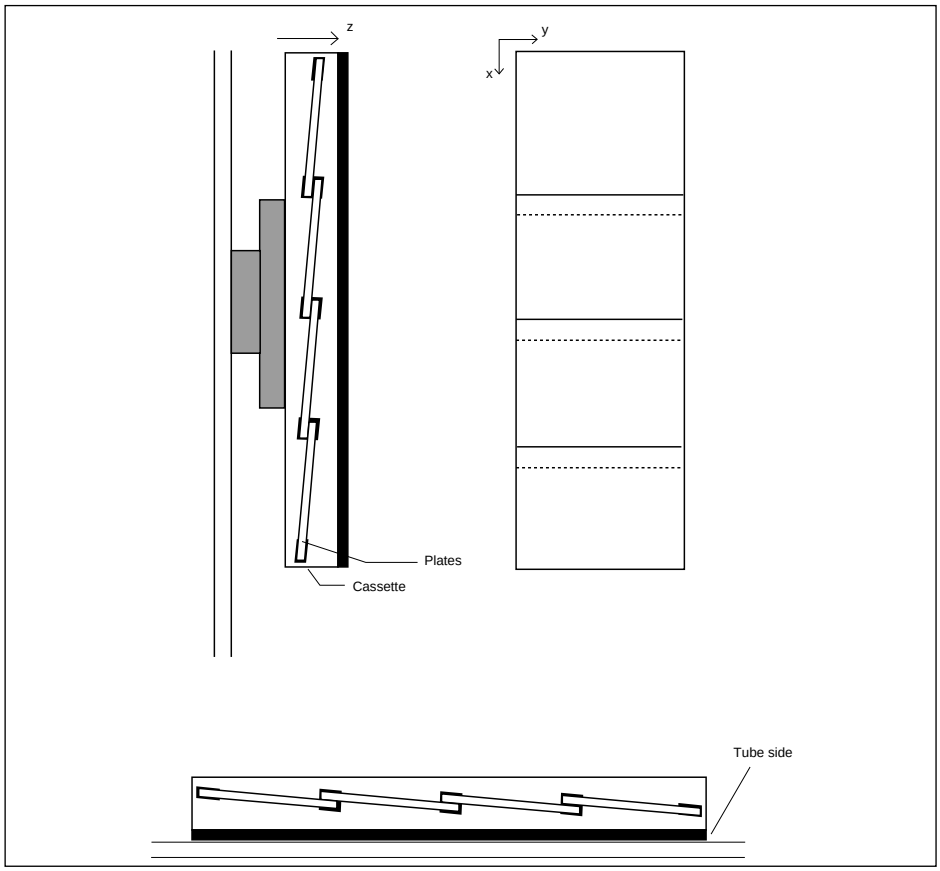
- Three 35 x 43 cm plates with a 35 x 120 cm cassette for a full-leg examination.

Making up the cassette

In order to make up the cassette, proceed as follows :

1 Put the first plate in the cassette on the extreme left-hand side. The plates phosphor side should be facing the black tube side of the cassette. Take care that the first (bottom of image) plate is completely exposed, as this is the reference plate.

2 Insert the remaining plates from left to right, as shown in the illustration below. All overlaps between the plates should be approximately 2 cm, except for the final one, which may need to be as much as 10 cm.



3 Close the cassette

4 Make sure that the special grid is in place, on the tube side of the cassette or in the cassette proper. Its line distance should be between 30 and 70 mm.

5 Use intensifying screens if appropriate.

6 The gradual filter is not necessary, as it can be simulated using Musica processing.

Exposure

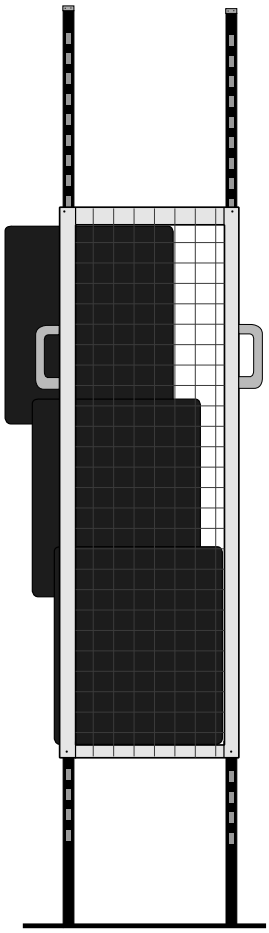
After having made up the cassette, proceed as follows :

1 Make a complete exposure of the cassette.

2 Open the cassette and put all the plates back in the ADC cassettes. This can be done in daylight.

Method 2 : several ADC cassettes in a special cassette-holder

The procedure to be followed is very similar to the first method using plates and cassettes.



1 Put three ADC Compact cassettes in the specially built cassette-holder, as shown above. The ADC cassettes used for this method are typically 14 x 17" cassettes.

2 Make a complete exposure of all three cassettes

3 Remove the cassettes from the cassette-holder and have them digitized

Note

When identifying the Full-Leg/Full-Spine sub-images using the ADC Compact Identification Software, see to it that the relevant sub-images are identified as "full spine" or "full leg" examinations to make sure that the constituent images are accurately aligned, in an upright position and processed using the same image processing parameters.

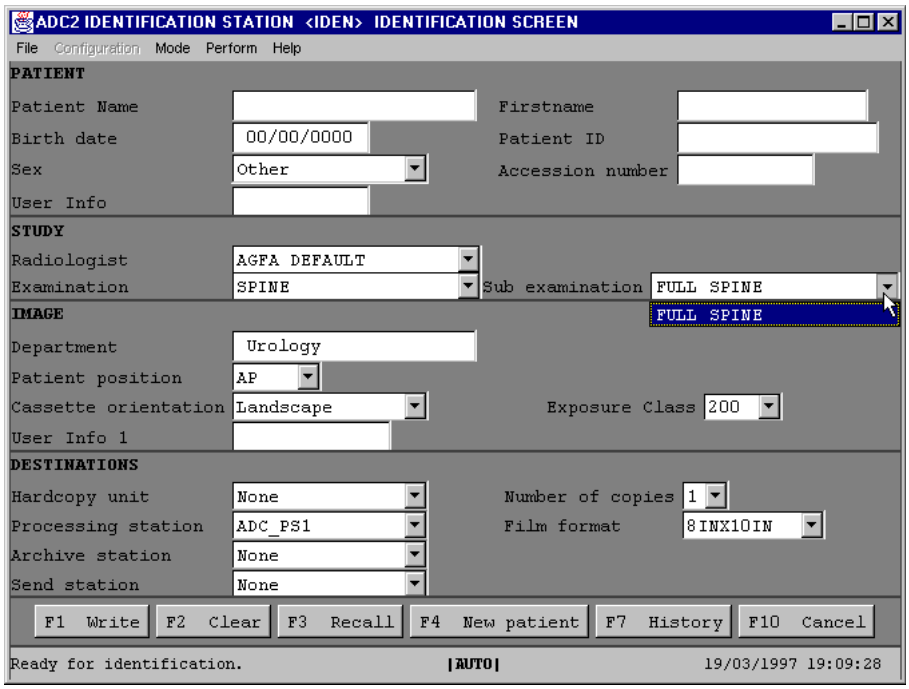


Image Stitching

In order to stitch the Full-Leg/Full-Spine sub-images into one composite image, proceed as follows:

Opening the Full-Leg/Full-Spine mode and selecting the image series, using the Controller button

1 Click the Controller button in the interactive processing browser screen. Then select [Full Leg/Spine] in the drop-down menu, as shown below.

Note

When the [Full-Leg/Full-Spine] option has been opened using the Controller drop-down menu, the browser screen that is returned is identical to the browser screen used in interactive image processing, with the exception that it features two buttons, viz. an [INFO] button and a [STITCH] button.

The Controller drop-down menu features the Full Leg/Spine functionality only when the ADC Compact Full-Leg/Full-Spine Application Software has been licensed.

2 On the Full-Leg/Full-Spine browser screen, select all sub-images that will make up the desired composite image, starting with the anatomically bottommost image first and ending with the topmost image, as shown in the sample screen below.

3 Only after the selection of an image from the Full-Leg/Full-Spine browser screen do the [INFO] and [STITCH] buttons become active.

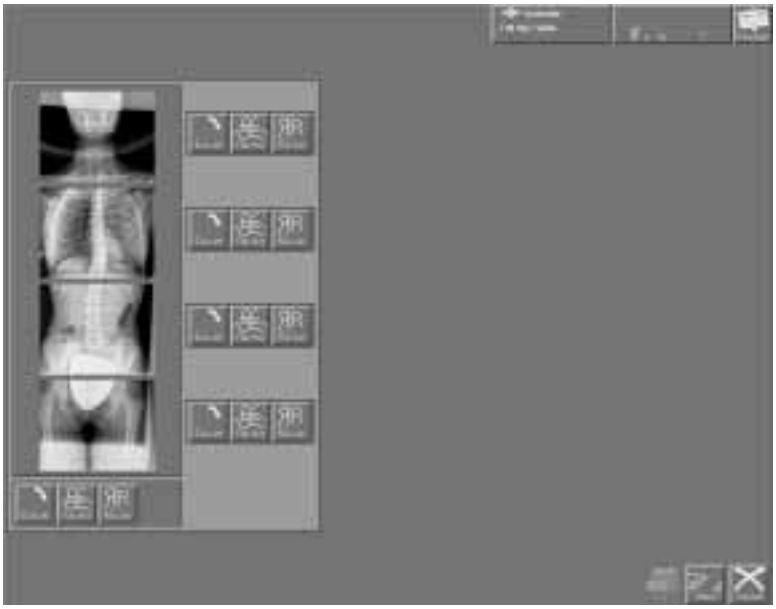
The [INFO] button provides access to information pertaining to any selected image, but unlike the Info screens used in the Interactive Processing browser mode, the information shown in the Full-Leg/Full-Spine browser mode cannot be modified or edited.

The [STITCH] button can only be activated when at least two images have been selected in the Full-Leg/Full-Spine browser screen.

Pressing the [STITCH] button initiates the first step in the stitching process.

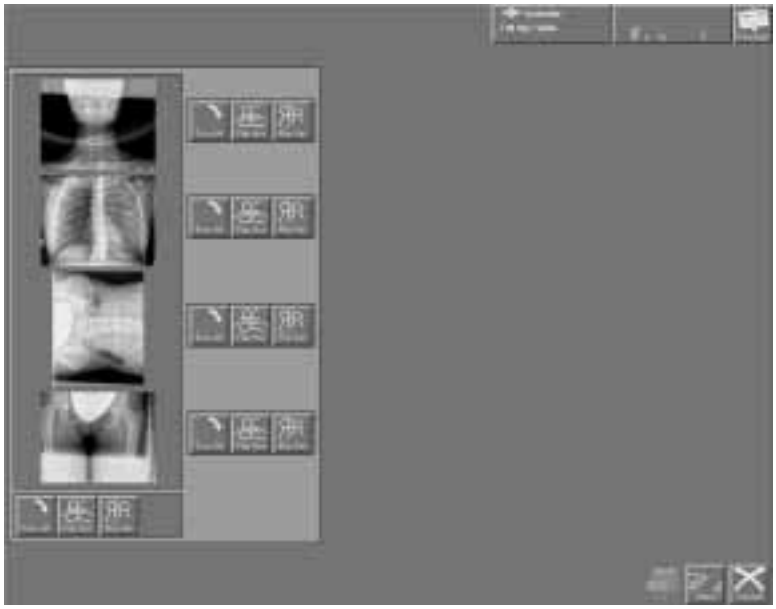
Full Leg / Full Spine mode and pre-composition adjustments

1 Pressing the [STITCH] button in the Full-Leg/Full-Spine browser screen, causes a screen to appear displaying all the constituent images, one above the other, on the left-hand side of the screen. The first selected image is displayed at the bottom.

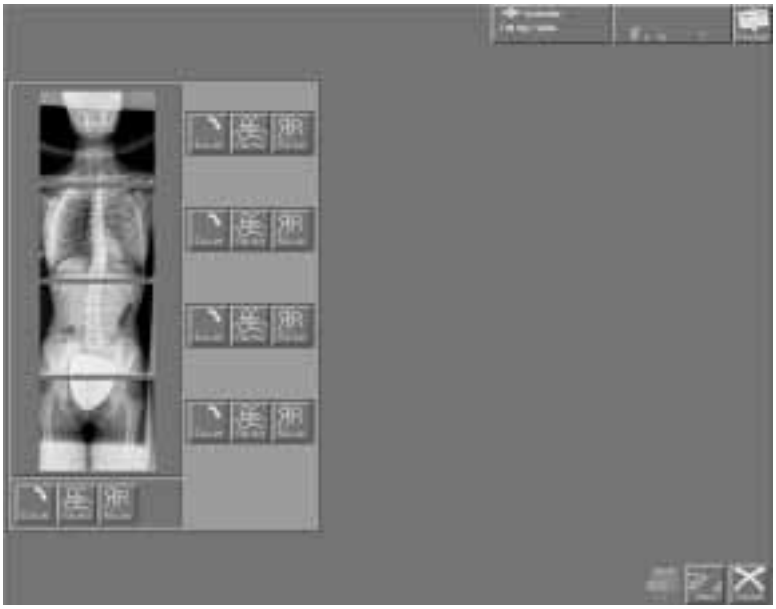


If the constituent images are not displayed in the proper order, press [CANCEL] to return to the Full-Leg/Full-Spine browser screen and restart the whole process, selecting the constituent images that will make up the desired composite image, starting with the anatomically bottommost image first and ending with the topmost image.

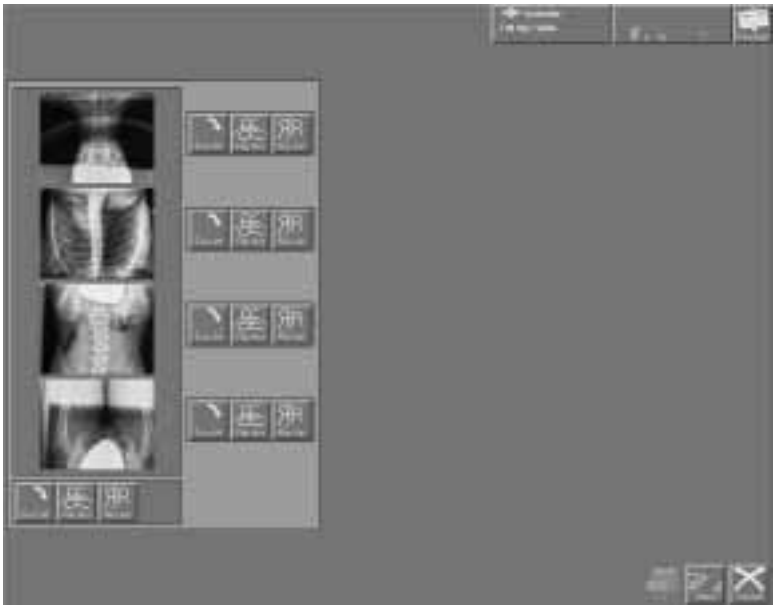
2 Make any adjustments that are necessary. Wrong orientation of any **individual** constituent image can be corrected by turning the image in 90° steps, or by flipping it horizontally or vertically, using the set of three orientation buttons on the right of each constituent image, as shown in the sample screen below.



3 In the sample screen above, the third "abdominal" image appears to be wrongly orientated. Press the [TURN 90°] button until the image is properly orientated and aligned. After the image has been rotated into its proper upright position, the system shows the following screen.



4 If **all images** are incorrectly orientated, as in the sample screen below, their orientation can be adjusted jointly using the bottommost set of orientation buttons.



Press the [TURN 90°] button in the bottommost set of buttons twice to rotate all four constituent images together by 180°.

The system shows a screen displaying the constituent images properly orientated.

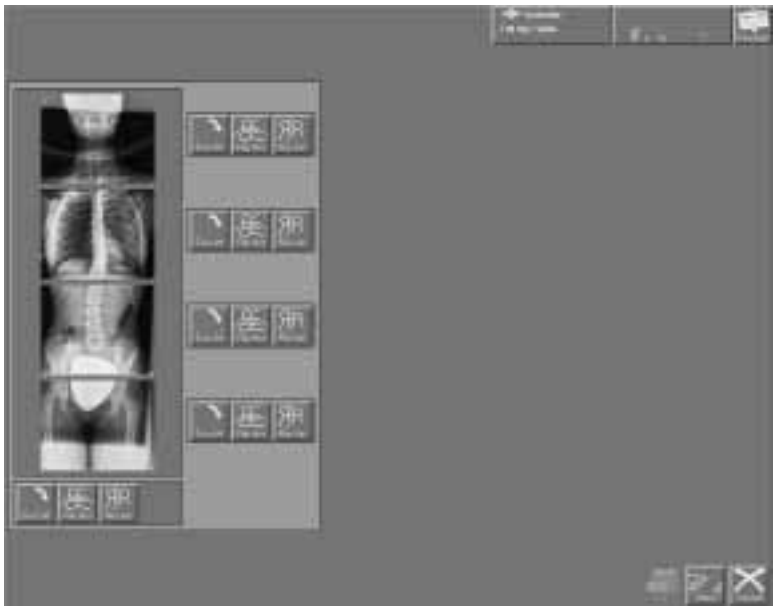
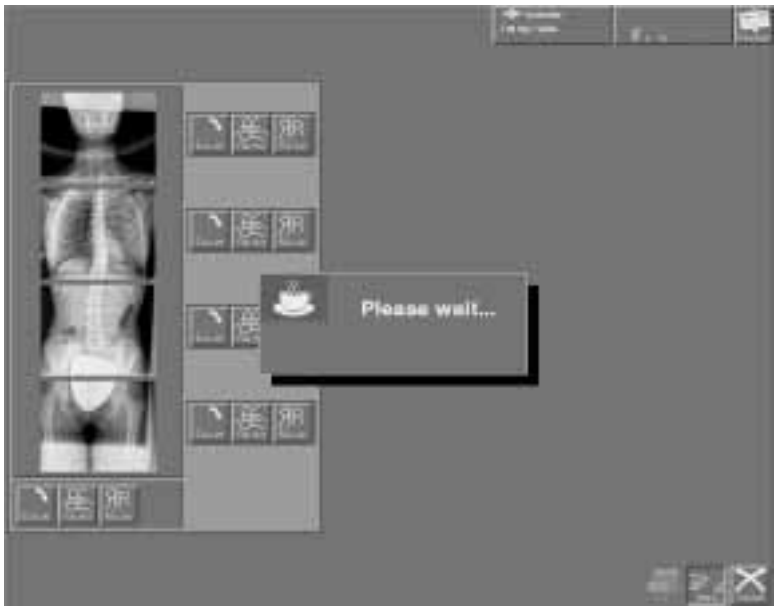


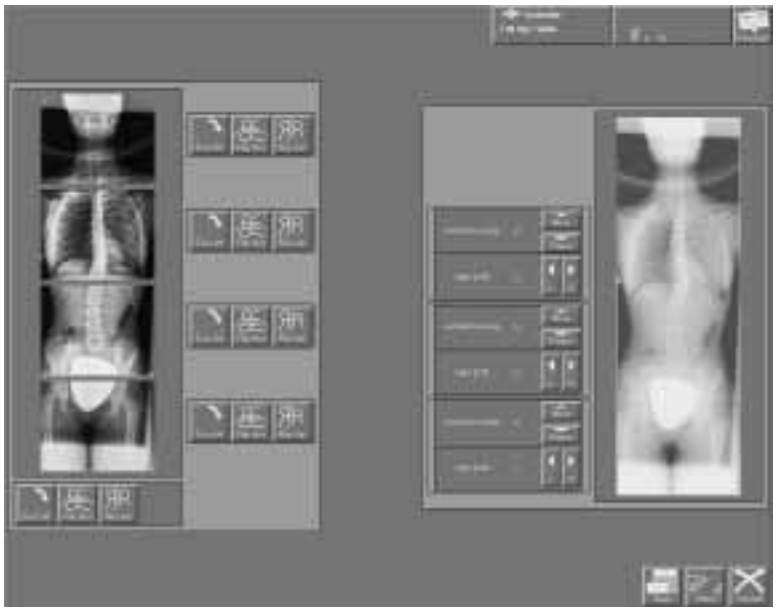
Image stitching proper

1 When the order and orientation of the constituent images is correct, press the [STITCH] button.



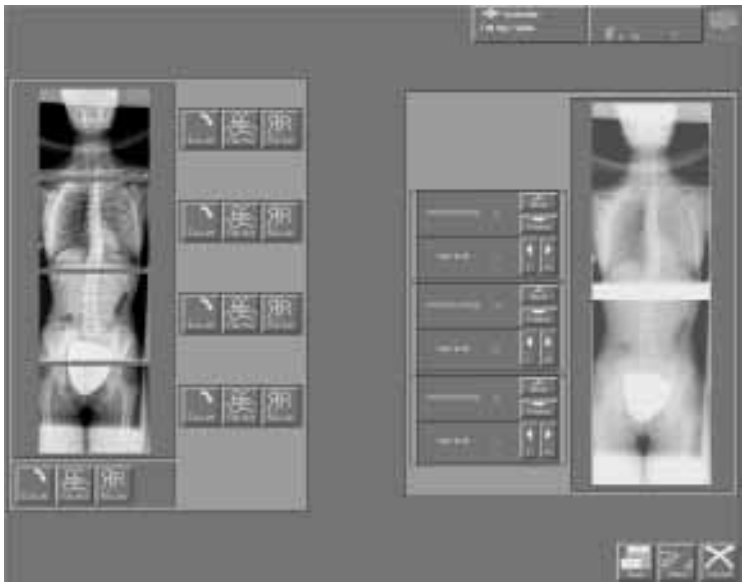
The ADC Compact Full-Leg/Full-Spine Application Software now assembles the sequence of constituent images into one composite image. A message asks you to wait until the total image has been calculated. This might take a few minutes because of the need for precision image rotation, skewing and deskewing operations and re-sampling of the image with retention of maximum image sharpness.

2 The resulting composite, "stitched" image is then displayed on the right.



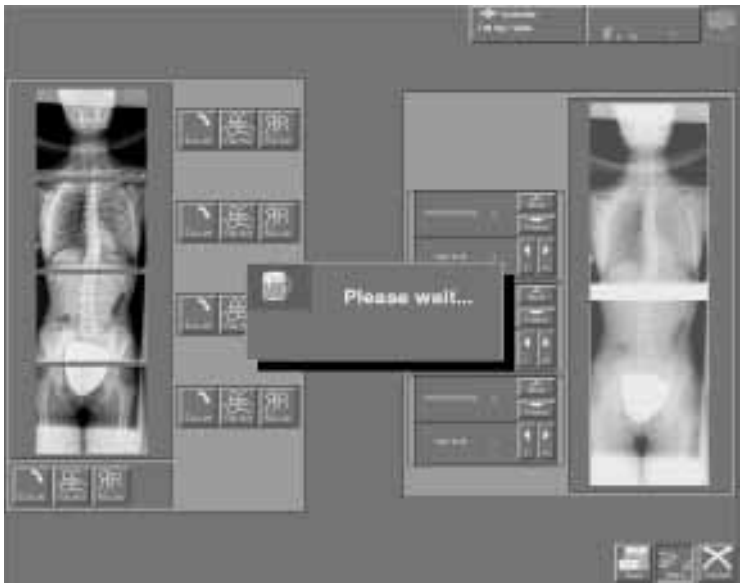
Manual correction

1 Where overlap values are very small, the overlap computation may be erroneous, due to there not being enough pixels for reliable computation of cross-correlation values.

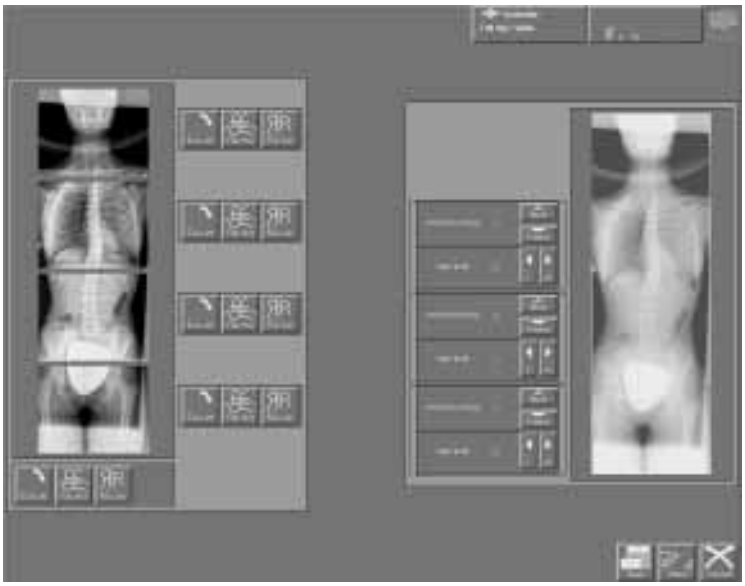


2 You can now manually correct, i.e. increase or decrease, the overlap between the constituent images vertically, using the [MORE] and [FEWER] correction buttons and, if necessary, shift the images to the right or to the left using the [L] and [R] buttons. These correction buttons appear to the left of the stitched image, one button for each image pair (1-2, 2-3 and 3-4).

3 Press [STITCH] a second time. This corrects the overlap value by the integral amount of Planfeld grid periods indicated by the vertical shift value. Although horizontal overlap errors are very unlikely to occur, a similar correction may be made to adjust the horizontal shift by an integral number of periods.



4 Again, a waiting message asks you to wait until the overlap has been re-calculated. The system then shows the stitched image with the corrected overlaps.



The stitched image is characterized by the presence of line-like sub-image separations. They are due to the non-scanned top portion of the second, third and fourth plate.

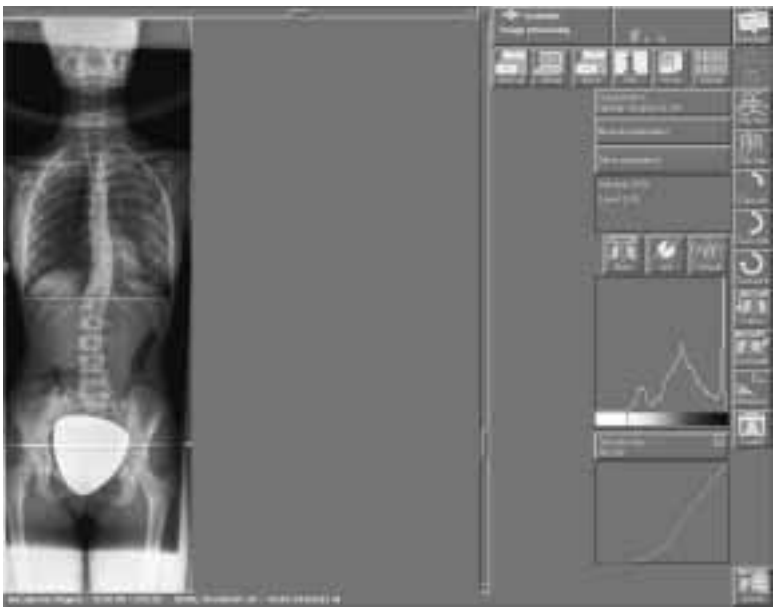
Returning to the Full-Leg/Full-Spine browser screen

1 Press [SAVE] to save the correct composite image. If [CANCEL] is pressed the stitching result is ignored and you then simply return to the Full-Leg/Full-Spine browser screen.

2 Pressing [SAVE] causes the stitched image to appear in the browser. The newly created composite image is a 12-bit pyramidal image, which has all the image processing features that were applied to the first, i.e. bottommost, constituent image. Patient data associated with the composite image are also those linked with the first constituent image.

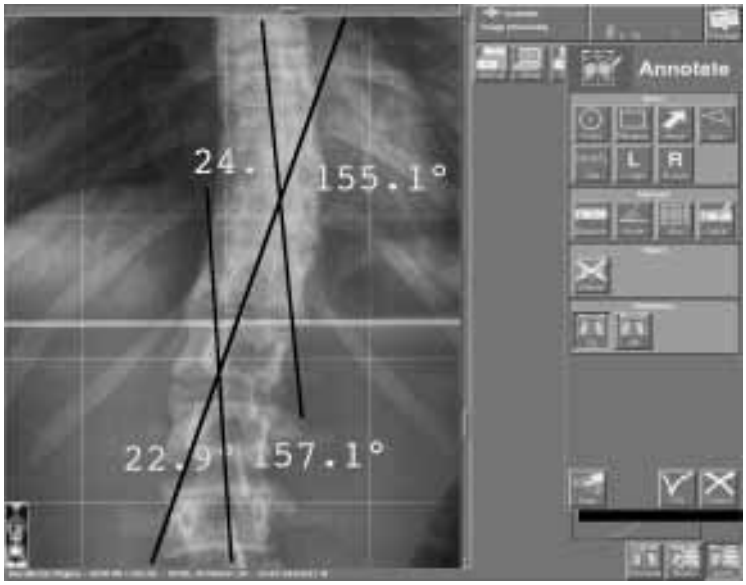
3 The newly composed image is now ready for operations such as

- MUSICA image enhancement



- enlargement of specific image portions

- annotation, analyzing and angle measurements



- printing, and so on.

For a more detailed description of the above image processing operations, refer to the relevant ADC Compact User Manuals.

Printed in Belgium
Published by Agfa-Gevaert N.V., B-2640 Mortsel-Belgium
2214A GB 199811