ImageJ plugin for semiautomatic measurement of roentgenological attachment level
User manual and installation instructions v. 1.1, June 2015

- The plugin is written by Gerald R. Torgersen[1] based on the requirements and input of Hans R Preus[2] et al.

  Project web: http://www.odont.uio.no/english/research/projects/periodontal-diseases/

  Publication: Preus, HR; Torgersen, GR.; Hansen, BF; Koldsland, OC; Aass, AM; Larheim, TA & Sandvik, L (2015). A new digital tool for radiographic bone level measurements in longitudinal studies. *BMC Oral Health*. ISSN 1472-6831.

Description

The plugin is written in the Java programming language to be run in the free open source image processing and analyzing application ImageJ[1]. The plugin saves the coordinates of the sites to a semicolon separated text file. A spreadsheet for calculation of distances and some proportions is provided with the plugin. The program is provided for free use under the GPL v3 license[2]. The author or the University of Oslo takes no responsibility for direct, indirect, incidental or consequential damages resulted by the plugin.
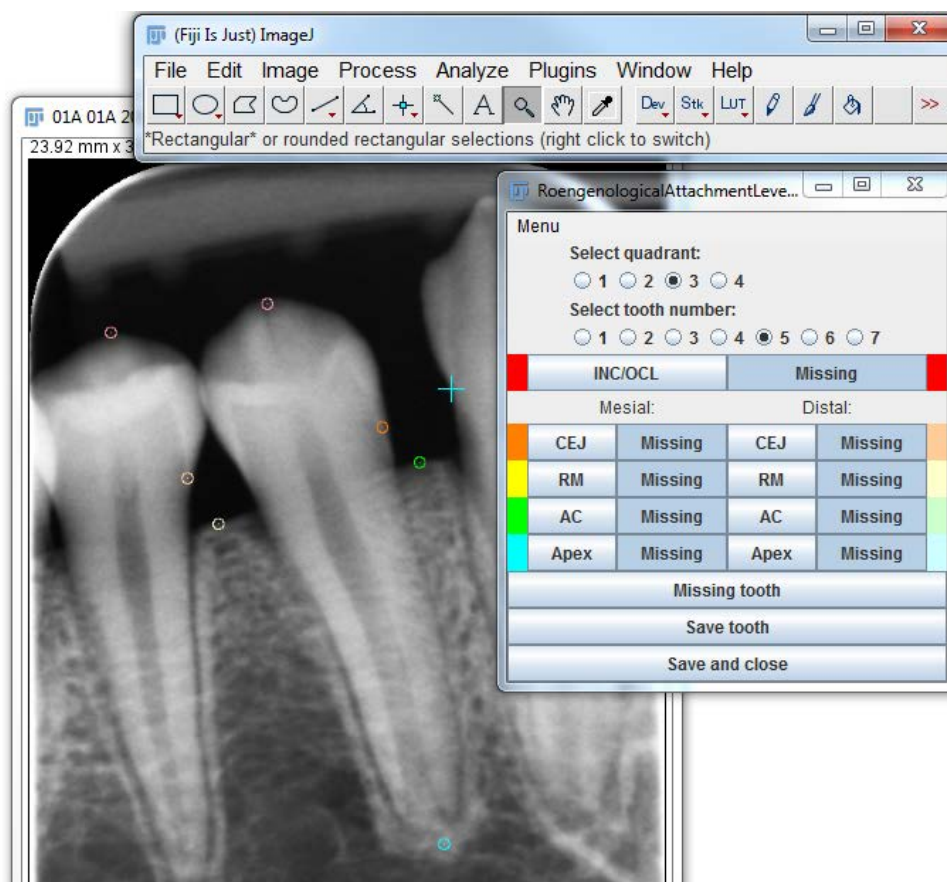

Figure 1 - Screenshot of plugin in use

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The sites

The sites marked on the radiographs are shown in Figure 2 and explained in Table 1. The horizontal (x) and vertical (y) coordinates of the sites are stored to the output file. The unit of measurement in the pictures EXIF data (e.g. pixel, cm or inch) is also written to the output file. Missing site coordinates are stored as the letter 'X' in the result file. The highest point of the Incisor or occlusal level is used for the INC/OCL site. For teeth with only one root the mesial root apex is used for the site Apex, for other teeth.
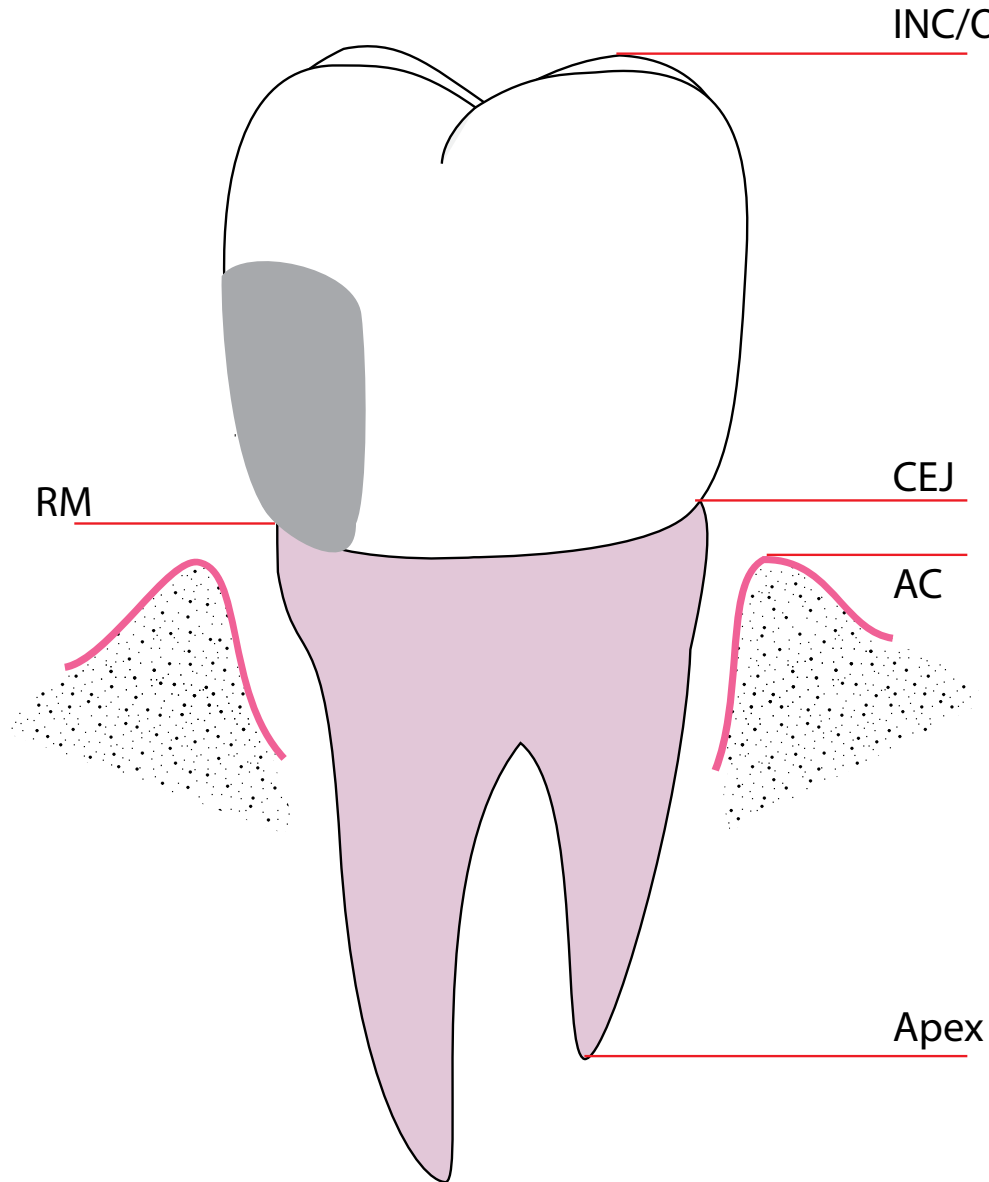

Figure 2 - Sites

Code	Site/ function
Apex	Apex
AC	Alveolar crest
CEJ	Cemento enamel junction
RM	Restoration margin (optional if CEJ is missing)
INC/OCL	Incisor- or occlusal level

Table 1 - Sites marked

Distances calculated

With the plugin there is also provided a spreadsheet for importing the data from the result file of the plugin. The spreadsheet calculates the distances shown in Figure 3. All distances are calculated in the vertical direction i. e. only the y coordinates are used in the calculations. Any other distance between the sites can be calculated by modifying the spreadsheet.
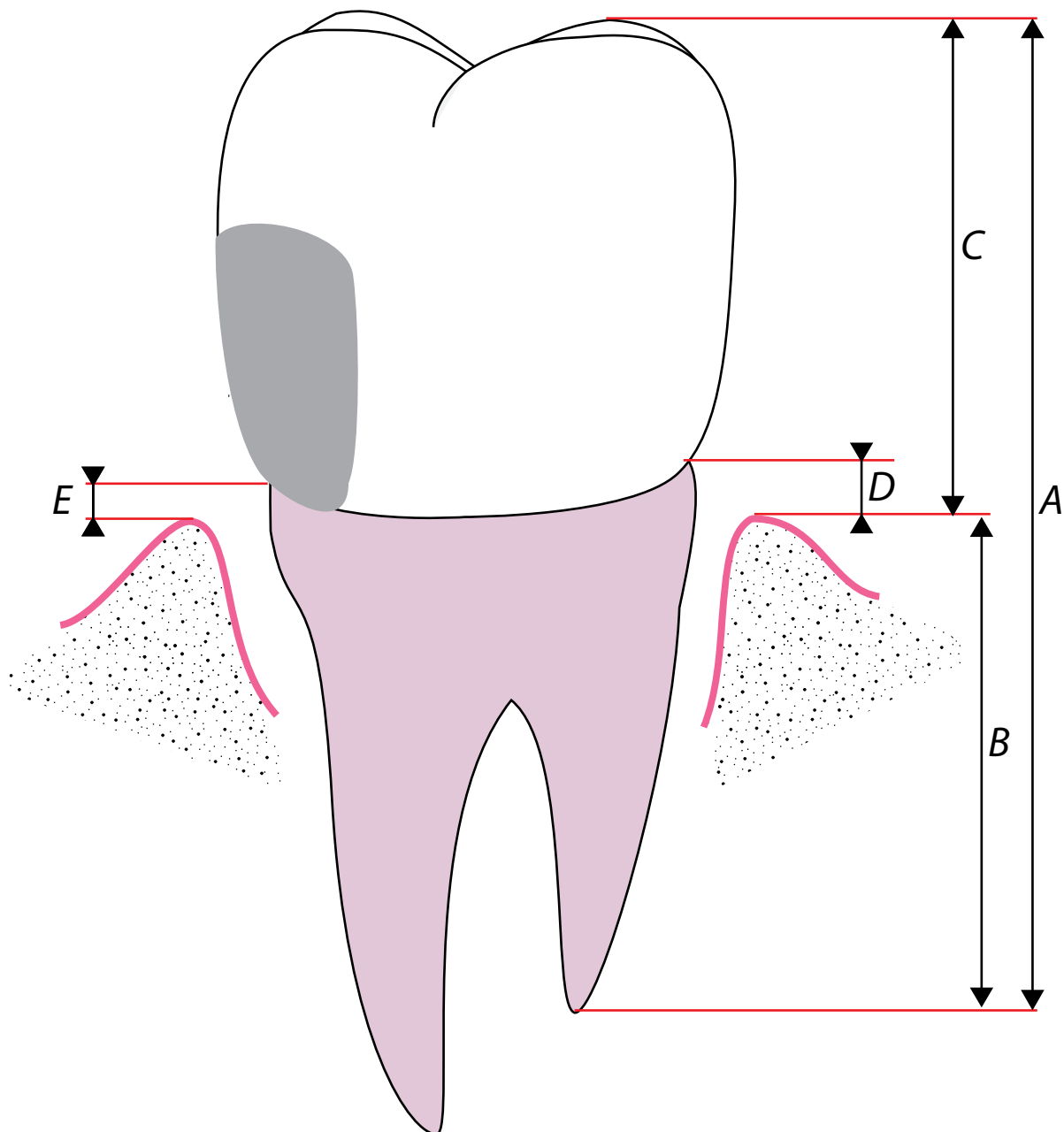

Figure 3 - Distances calculated

Distance	Use/explanation
A	apex – INC/OCL the preferred distance for proportions
B	apex – CEJ if INC/OCL not available
C	AC – INC/OCL if apex not available
D	AC – CEJ the preferred distance for proportions
E	AC – RM if D is not available

Table 2 - Explanation of distances calculated

Proportions calculated

The project originating the program uses proportions between different distances of the sites to quantify the attachment loss. Therefore some formulas calculating those proportions are provided in the spreadsheet.

The following proportions are calculated (shown in priority order):

$$\frac{D}{A}, \frac{D}{B}, \frac{D}{C}, \text{ if CEJ is available or}$$

$$\frac{E}{A}, \frac{E}{B}, \frac{E}{C} \text{ if CEJ is missing.}$$

Proportions where one or both sites are missing in the measurement data are shown as NA (not available).

Copy of file with sites marked

When the last tooth in an image is saved, the program makes a copy of the image (Figure 4) with the marks stored in the folder of the original image.

The file name is of the form:
Measured_YYYY-MM-DD-hh.mm-<original filename>.jpg

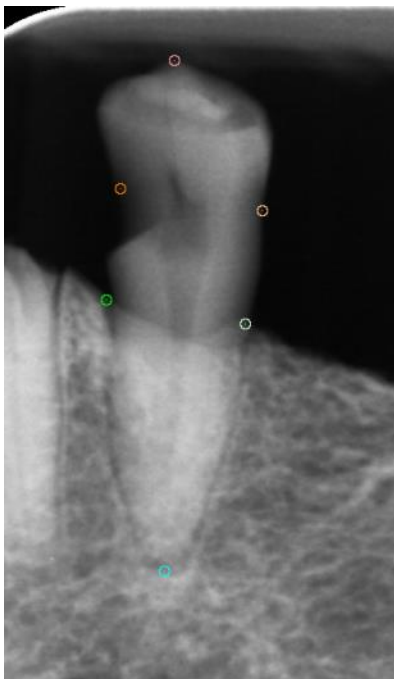The timestamp is the date and time saving of the file (Save and close).

Figure 4 - Example of the section of the copy with sites marked

The result file

The images and measurement results

All patient images have to be stored in folders, one folder for each patient inside a root folder (). The ";"-separated data file (csv format) containing the coordinates and other data from the measurements (measurements.txt) will be generated in the root folder. The name of the leaf folder together with the image file name is stored in the corresponding data row.
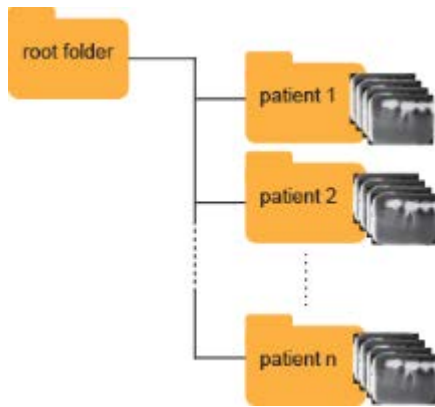
Figure 5 - Folder structure for analysis

The details of the file format are given in Figure 5.

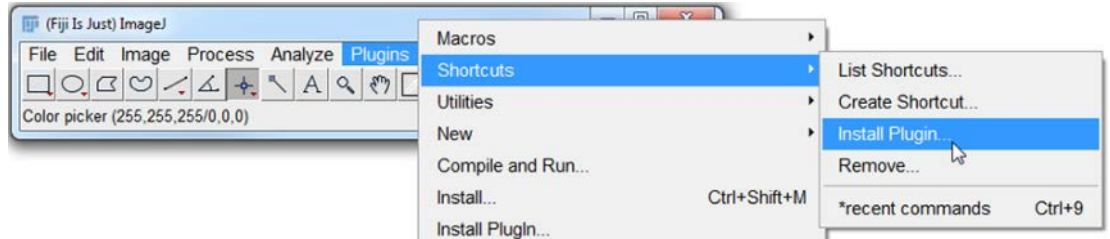# Appendix A - Installing the plugin

Installation of the plugin:

1. Copy the file RoengenologicalAttachmentLevelAnalyzer_.jar to the plugins folder of the ImageJ program
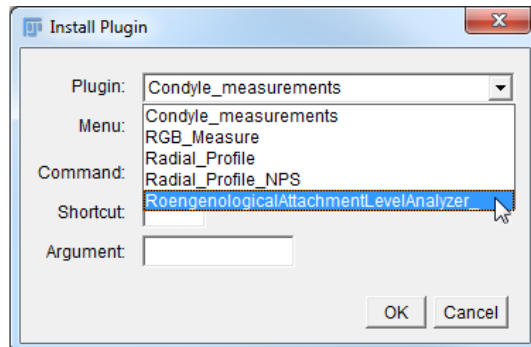2. Start ImageJ and the plugin will be listed in the Plugins menu

Set up a keyboard shortcut to start the plugin

To start the plugin directly by pressing a key (e.g. F5) a keyboard shortcut has to be set:
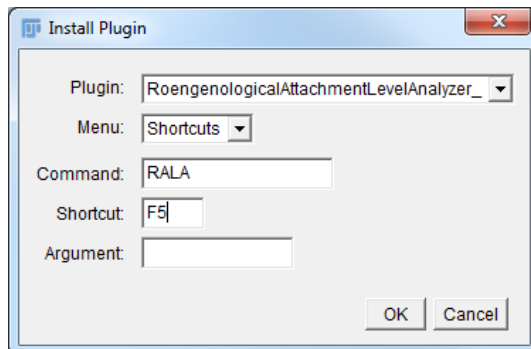
    a. In ImageJ menu: Plugins – Shortcuts – Install Plugin

    b. Find the plugin in the scroll-down list

    c. Write something in the line command (the field is required but not used)

    d. Choose shortcut e.g. F5

    e. Click OK

Appendix B - Using the plugin

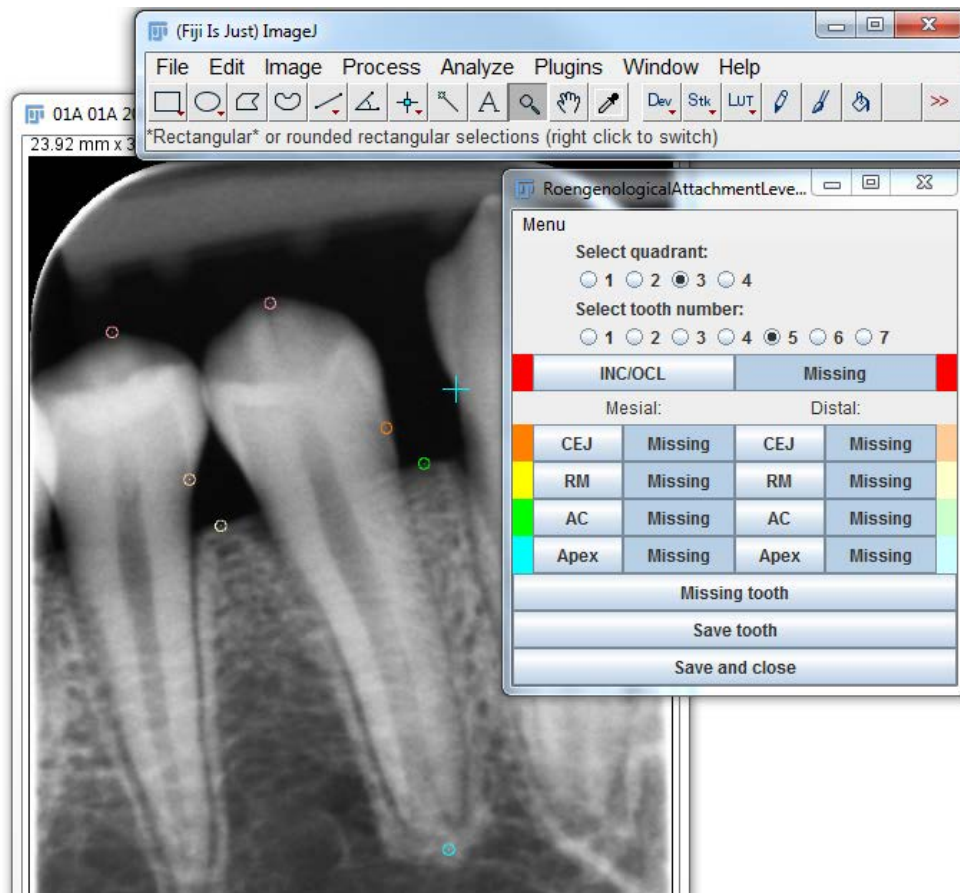The x-ray has to be opened in ImageJ. The plugin has to be installed and a shortcut key can be assigned.

Figure 6 - The plugin in use (points placed by programmer)

Step

1. Open x-ray to measure
2. Start plugin (plugins menu or shortcut key)
3. Select quadrant and tooth number (other buttons are disabled until tooth is selected)
4. Sites not entered are stored as missing
5. Use missing button to delete sites tagged incorrectly
6. Sites can be adjusted by adding them again, the original point will be replaced
7. Click "Save teeth" to add measurements to the result file and start measuring next teeth (start over at point 3)
8. After measuring the last teeth on the X-ray click "Save and close" to:
   - Save data to the result file
   - Close the X-ray
   - Generate a copy of the X-ray with the measurement lines burnt in for documentation purposes

Appendix C - The format of the result file

The coordinates recorded in the result file are given in the unit shown in the result line. Coordinates are in respect to the upper left corner of the X-ray and increase to the right for the x-coordinate and down for the y-coordinate (Figure 7).

Figure 7 - The coordinate system in the images

The line format
Each line of the result file has the following structure:

Folder (leaf node) \filename; measurement data and time;
Unit (of length); Teeth (quadrant, number);
INC/OCL x; INC/OCL y; CEJM x; CEJM y; CEJD x; CEJD y;
RMM x; RMM y; RMD x; RMD y; ACM x; ACM y; ACD x; ACD y;
ApexM x; ApexM y; ApexD x; ApexD y;

Explication of codes
The letter after side code (M or D) stands for mesial or distal.

Appendix D - Obtaining and installing ImageJ

The ImageJ Software
ImageJ is a public domain Java image processing program inspired by NIH Image for the Macintosh. It runs, either as an online applet or as a downloadable application, on any computer with a Java 1.4 or later virtual machine. The program is available for Windows, Mac and Linux.

Installing the ImageJ Software
The software can be downloaded from the ImageJ website http://rsbweb.nih.gov/ij. Refer to the online documentation on how to install the program.