Computerized Skeletal Age Assessment

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Assessment of skeletal age to determine physiological maturity and growth potential is important in planning orthodontic treatment of growing patients. Current methods rely on radiographic analysis of maturational indicators on the hand and wrist bones[1] and cervical vertebrae.[2,3]

A computerized method for assessing skeletal age would be more objective, more reproducible, faster, and simpler than manual methods. Considering that the cervical vertebrae already appear in routine lateral cephalograms obtained for orthodontic diagnosis, they could be used in a computerized system as a convenient, reliable indicator of skeletal maturity.[4,5]

We have developed a computer algorithm to assess skeletal age based on a mathematical formula devised by Sato and colleagues, which uses measurements of the widths and heights of the third and fourth cervical vertebrae as viewed on a lateral cephalogram.[2,3] Our software program, Skeletal Age 1.0, was developed using the Micro-soft .NET Framework* and is freely available for download.** Currently supported operating systems are Windows Vista and Windows XP.

Using the Software

The three main areas of the application interface (Fig. 1) are:
1. Record Menu, including the operating commands.
2. Canvas area, where either the cephalogram is loaded from a digital file (Image Mode) or a hard copy of the x-ray is placed directly on the monitor (On-Screen Mode).
3. Calculated Age, which shows the patient's skeletal age as the assessment is performed.

To create a patient record in Image Mode,

*Microsoft .NET Framework 3.5 Service Pack 1, Microsoft Corporation, Redmond, WA; http://go.microsoft.com/fwlink/?linkid=124150.

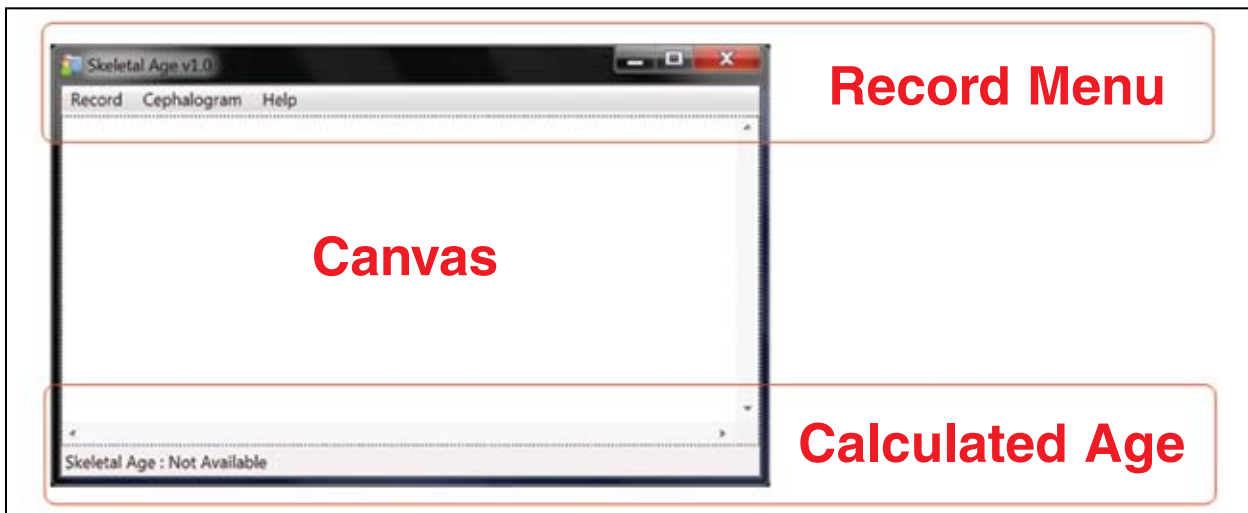**www.iorth.net/home/skeletal-age.

Fig. 1 Skeletal Age 1.0 application interface.

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click on Record>New>Using Digital Cephalogram. A dialog box will appear asking for the location of the stored digital or scanned cephalometric image file. The software can import files in JPG, TIFF, BMP, or PNG formats. The resulting screen includes the cephalogram along with preliminary graphic outlines of vertebrae 3 and 4 (Fig. 2).

When using On-Screen Mode, click instead on Record>New>Using Computer Monitor. The vertebral outlines appear on the screen alone, along with four orientation marks, and the user places the lateral cephalometric radiograph over the computer monitor (Fig. 3). Orientation marks can be moved as necessary, using the mouse, to match orientation marks on the radiograph.
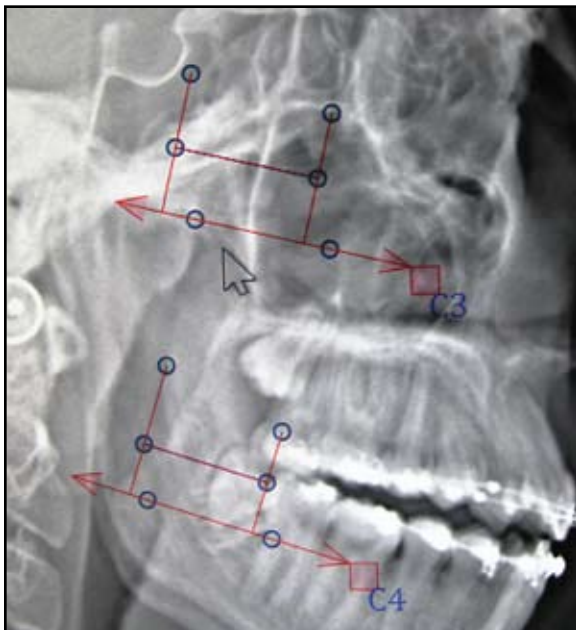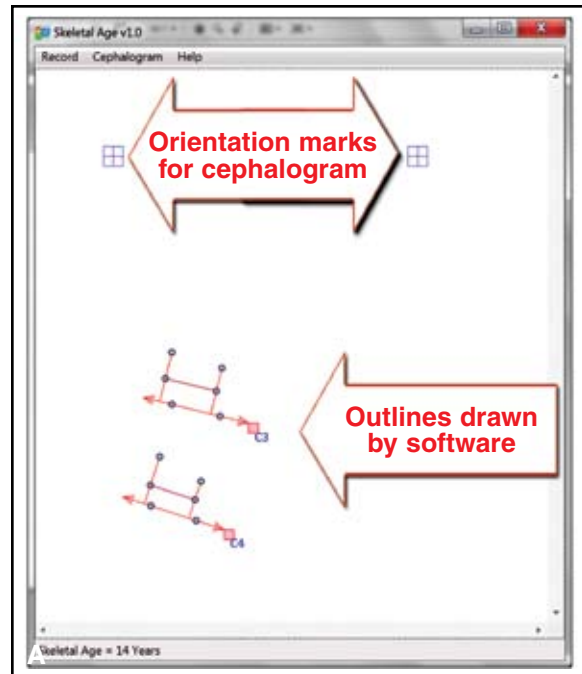

Fig. 2 Close-up of newly created record in Image Mode, with preliminary vertebral outlines added by software over digital cephalometric image. Operator uses mouse to drag each vertebral outline to appropriate area of radiograph.

Fig. 3 On-Screen Mode. A. Newly created record. B. Cephalometric x-ray placed directly on computer monitor.

In both Image and On-Screen modes, each vertebra is represented by a graphic outline (Fig. 4). A rectangular anchor (labeled C3 or C4) is the control point for moving the entire vertebral outline to the appropriate location on the screen.

The blue circles represent six landmark points on each vertebral body: the antero- and postero-superior points, the antero- and postero-midpoints, and the antero- and postero-inferior points. Four red lines are drawn by the software: a baseline connecting the antero- and postero-inferior points; an anterior vertical line, perpen-
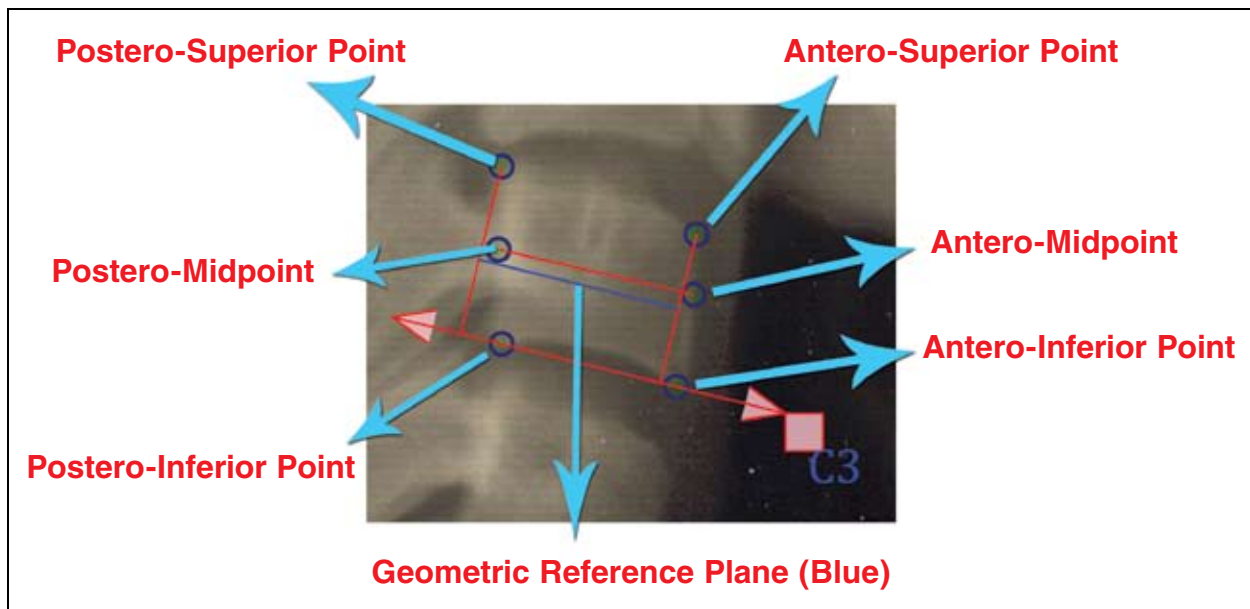

Fig. 4 Cervical vertebral landmarks included in software analysis. Blue reference plane appears after operator places superior and inferior points (points 1-4 in Fig. 5) with mouse.
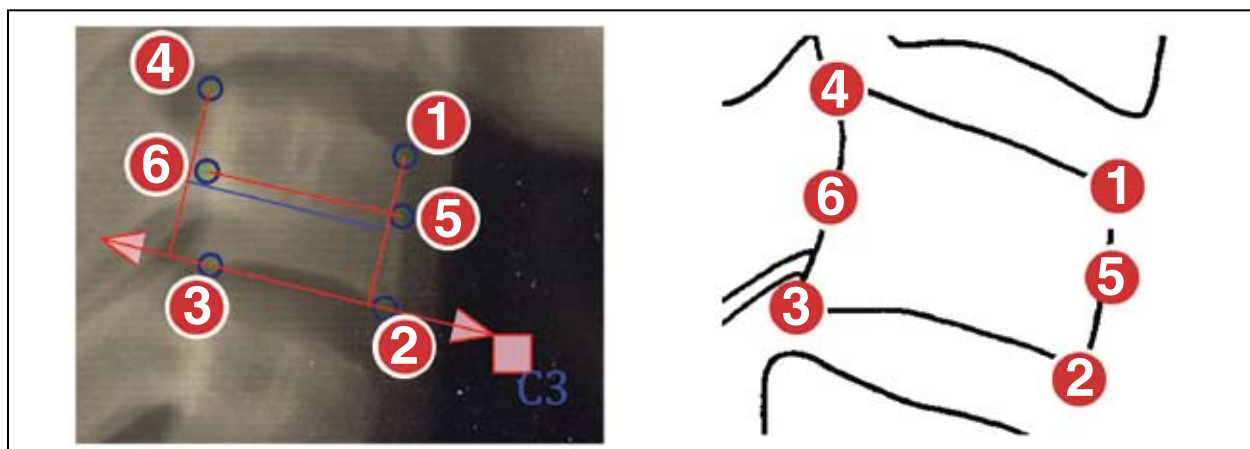

Fig. 5 Blue circles moved by operator to indicate anatomical landmarks, with inferior and superior points placed first, followed by midpoints.

dicular to the baseline, which measures the distance from the antero-superior point to the baseline; a posterior vertical line, perpendicular to the baseline, which measures the distance from the postero-superior point to the baseline; and a horizontal

Skeletal Age = 13.7 Years

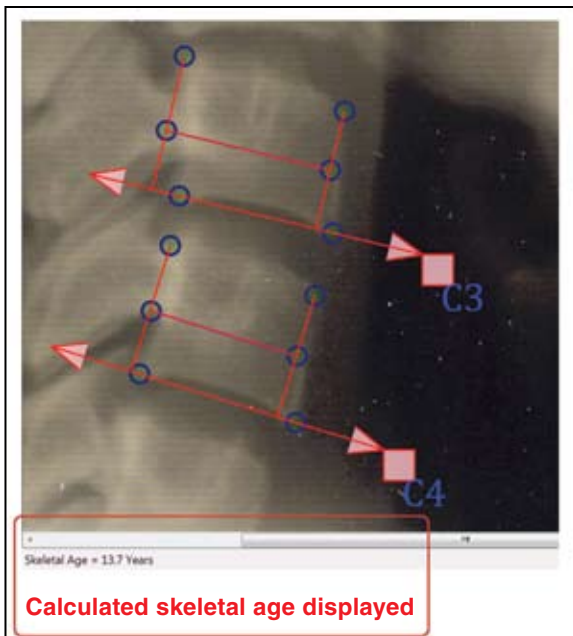**Calculated skeletal age displayed**

Fig. 6 Calculated skeletal age. (Blue midplane lines added by software are now covered by red horizontal midlines, after operator's placement of antero- and postero-midpoints.)

midline, which measures the distance between the antero- and postero-midpoints.

The operator moves each vertebral landmark indicator (blue circle) to the appropriate point on the cephalogram using the mouse, with the antero- and postero-midpoints placed last (Fig. 5). A blue reference line appears at the midplane of the vertebral body outline after placement of the first four landmarks; the midpoint landmarks should then be positioned so that the red horizontal midline completely overlies the blue reference line.

Once all six landmarks have been placed, the patient's calculated skeletal age appears at the bottom of the screen (Fig. 6). When saving the patient's file, the software automatically adds the extension .SAGE to the record. A three-dimensional version of the program is under development.

REFERENCES

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