

A Software Tool for Measurement of Facial Parameters

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Abstract: The object of this paper is to introduce a freeware software tool designed to simplify taking measurements of anthropometric facial parameters. Measurement of facial parameters is often needed for rhinoplastic, dental and aesthetic surgical procedures. By measuring parameters of crucial importance, the surgeon can evaluate the condition of the patient. Measurement of parameters before and after surgery also provides a way of assessing results of the surgery. The measurement process is not difficult but tedious due to accuracy requirements. The software tool presented in this study can be used to work with patients' photo files and provides a way of measuring popular facial parameters easily and accurately. The paper describes how the software tool should be used for measuring facial parameters correctly. The tool is developed in Java to make it portable over different platforms and can be used to export patient's measurements to a spreadsheet or database automatically. Software is available for download as freeware for license free use.

Keywords: Surface anthropometry, rhinoplasty, aesthetics, cosmetic techniques, computer software, software tools, photography.

1. INTRODUCTION

Facial surface anthropometry is a term used for describing measurement of facial features and the method of recording positions of these features [1]. Facial measurements are based on spatial correspondence between definable points on the face. There are more than 20 landmarks and parameters of interest for medical and dental professionals that deal with face [2]. Currently there are three methods used for making facial measurements [3]. These methods are;

1. Manual anthropometry,
2. 2D photography,
3. 3D stereo-photogrammetry

3D stereo-photogrammetry uses laser scanners and records image as a 3D virtual object which can be rotated and viewed from different aspects. The tool has proven itself as an excellent tool for cranio-facial applications [4-5]. The obvious drawback of the method is the cost of equipment. 3D Laser scanners typically can be found in Medical Photography departments of hospitals.

Manual anthropometry makes surface measurements using sliding and spreading calipers and flexible measuring tape [6-8]. The techniques is accessible due to low cost of the tools but major drawbacks are due to excessive time involved in taking measurement and the fact that during measurement the tools distorts the soft tissue and introduces errors into measurements [8-10].

2D photography is an alternative way to manual anthropometry by taking photos of patient with their head positioned in special orientation with their Frankfort plane horizontal to the ground. Frankfort plane is a hypothetical line used for correct head positioning and defined as line connecting the superior border of the external auditory meatus with the infraorbital rim. In this method measurements are taken from photos rather than from the patient directly [11-13]. Making measurements from photos are more convenient, but locating bony structures under the skin requires palpation [14]. Another problem with 2D photography measurement is the difficulty of measurement of curved surfaces.

Comparison studies concluded that all three methods have comparable accuracy in producing results [3]. The software tool developed in this study is designed for 2D photography method of measurement using digital files and optimized for facial surface anthropomorphic measurements.

2. SUBJECTS AND METHODS

2.1. Digital Photography Essentials

The software tool which is introduced in this study is designed to extract parameters from 2D photos of the patient. Rather than using rulers and protractors on printed photos, measurements can be done directly from digital photos of the patient. The tool generates the results in a format suitable to be exported to spreadsheets and databases.

Proper use of camera for taking photos of plastic surgery patients is well established and documented by many experts [15]. Availability of inexpensive, high resolution digital cameras has made digital photography very convenient and attractive. Although it may vary depending on the particular camera used, for most digital cameras, the camera should be positioned approximately 1-1.5 meter distance from the

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patient and should be placed on a tripod which is raised to the ear level of the patient. Ideally, when viewed from the viewfinder or LCD display, the patient's face should be covering approximately 50% of the viewfinder area. Placing two light sources on both sides of the camera, spaced one meter apart can provide shadow free illumination of the patient's face. Light sources should be at the same level with the camera and distance from the patient should be similar to the distance between camera and the patient. Background can be any uncluttered wall or curtain of desired color. Use of camera flash is not necessary if the ambient light is strong enough to illuminate the subject.

Minimum acceptable camera resolution of 640 X 480 pixels is necessary for the patient photos, although higher resolutions around 1000 X 700 pixels is recommended. Ultra high resolutions do not necessarily provide additional information on the photo and makes image handling more difficult. Software presented in this study is designed to work with any screen resolution. The selected screen resolution indirectly affects the resolution of the images. It is recommended to set the camera resolution slightly less than the monitor screen resolution for optimum use. As an example, if your screen resolution is set to 1280 X 760, your camera resolution is recommended to be around 1000 X 700 pixels (or nearest resolution provided by the camera).

2.2. Installation and Set up of Software Tool

The software is developed in Java language and is compatible with all recent versions of Microsoft Windows like Vista or XP. The setup file should be downloaded and executed to install the package in the computer. After installation, "Face Master" icon appears in the programs area.

2.3. Method of Making measurements with the Tool

The software tool is designed to make angular and ratio metric measurements of any facial features, but it provides assistance for the following frequently used facial parameters:

- Nasofrontal angle,
- Nasal projection ratio,
- Nasofacial angle,
- Nasomental angle,
- Nasolabial angle,
- Rule of the third ratio,
- Rule of the fifth ratio,
- Equilateral triangle rule ratio.

These parameters are well defined with respect to facial landmarks which are shown in Fig. (1). For measurement of these parameters, widely accepted and practiced definitions are used [16-21]. All the parameters listed above are associated with special icons displayed on the upper left side of the work area.

The software tool works with three different photographic views of the patient. Frontal view, which shows the patient from the front side, is used for measurement of rule

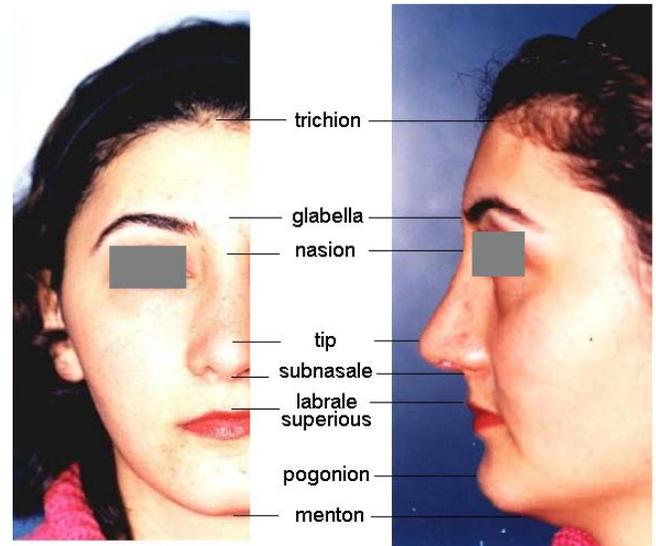


Fig. (1). Some of the major facial landmarks.

of third and rule of fifth parameters. Base view photograph, which shows the base view of the nose, is used for measurement of equilateral triangle rule parameter. The lateral view, which shows the profile view of the patient, is used for measurement of the rest of the parameters. Different photographic views of the patient can be loaded into the workspace one at a time and the measured parameters can be transferred to the patient's spreadsheet without disrupting the continuity of the measurement process. Fig. (2) shows the base, frontal and lateral views of the patient together.

Upon selecting the "New" patient from file menu, the patient's spreadsheet is cleared and prepared for a new patient. Fig. (3) shows the lateral view of the patient loaded into the workspace. Selecting "Save" feature from the file menu saves the patient's spreadsheet in excel format. Specific icons and help files are prepared for eight of the most popular parameters listed above and these icons are readily accessible from the toolbar area. Other parameters can also be measured, as long as user records the measurements manually. The software tool can be used to measure most facial parameters of interest. Most frequently used facial parameters and how they are measured using the tool is explained in the following sections.



Fig. (2). Base, frontal and lateral photos of a patient needed for measurement.

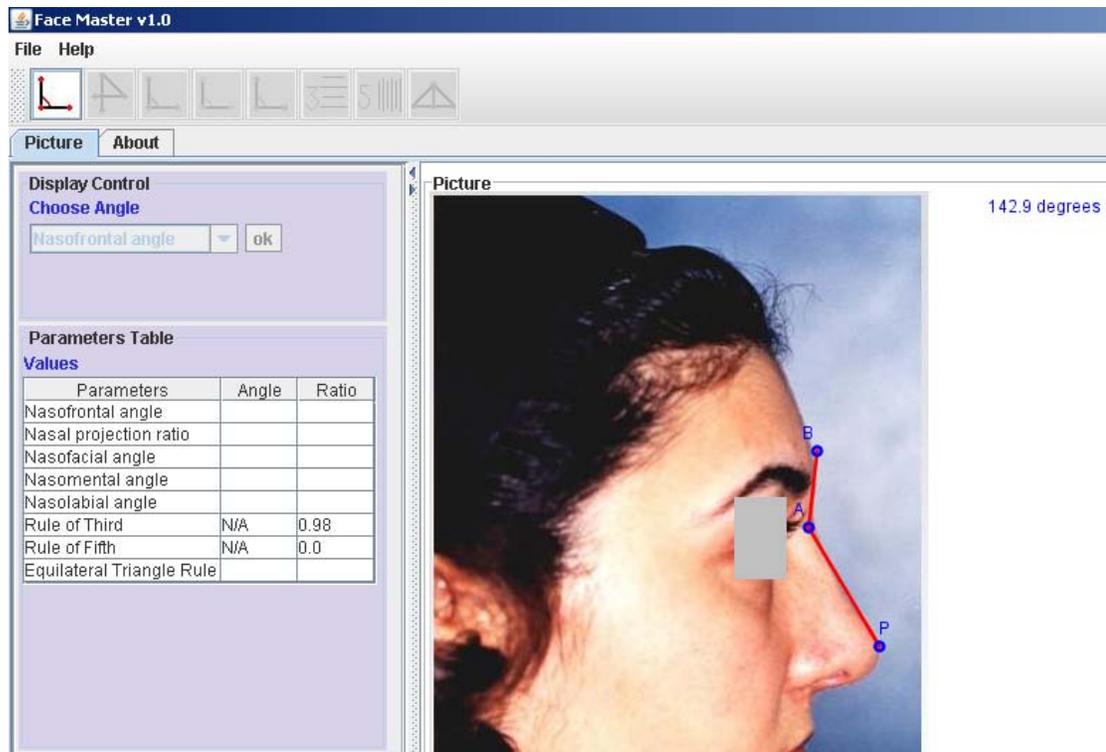


Fig. (3). Nasofrontal tool with handles in place and displaying measurement interactively.

2.4. Nasofrontal Angle Measurement Method

Nasofrontal angle is described as the angle between glabella-to-nasion line and the nasion-to-tip line. To measure this angle, first load the lateral image of the patient, and then click on the nasofrontal tool icon displayed on the upper left side of the workspace.

Upon clicking on the nasofrontal tool icon, a widget with handles labeled B, A and P appears on the screen. Handles can be dragged to any location on the screen by clicking on the left mouse button and dragging it. Pressing “shift” key while dragging the handles restricts the movement of the handle to only horizontal direction. Pressing “alt” key and dragging restricts the movement to vertical direction. By dragging the corners, handle A is placed on nasion, handle B is placed on glabella and handle P is placed on the tip. On the upper right hand side of the workspace, the measured angle is displayed instantaneously and upon clicking the icon the measurement is transferred to parameter table.

Nasomental and Nasolabial angle parameters are measured in a similar fashion by using their special icons. Help corner located on the right hand side provides help regarding where the handles are supposed to be located on the photograph.

2.5. Nasal Tip Projection Measurement Method

Nasal tip projection is a parameter which indicates how far the nose protrudes from the face. There are several different ways this parameter can be measured. The software tool makes the measurement using the technique described by Goode [17, 18]. According to this method, the length of a horizontal line drawn from alar-crease-to-the-tip is divided

by the length of line drawn from nasion-to-tip should give a ratio of 0.55 to 0.6. The horizontal line should be parallel to the Frankfort plane. Since the patient has been photographed with Frankfort plane horizontal to the ground, alar-crease-to-the-tip line should also be parallel to the ground. Division of these two lines gives a ratio, which is known as the nasal projection ratio. To measure this ratio using the software tool, nasal projection ratio icon is clicked which displays a triangle with handles at the corners. The displayed triangle is placed on the landmarks as shown in Fig. (4).

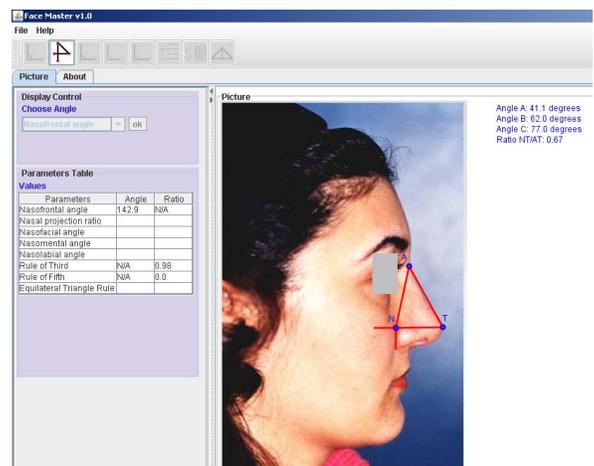


Fig. (4). Placement of handles for measuring nasal projection ratio.

Handle A is placed on the nasion, and handle T is placed at the tip. Handle N is placed on the alar-crease in such a way that lower extension of AN line and the NT line makes 90 degree angle. When this happens, NT is parallel to the ground and to the Frankfort plane. For the case given in Fig.

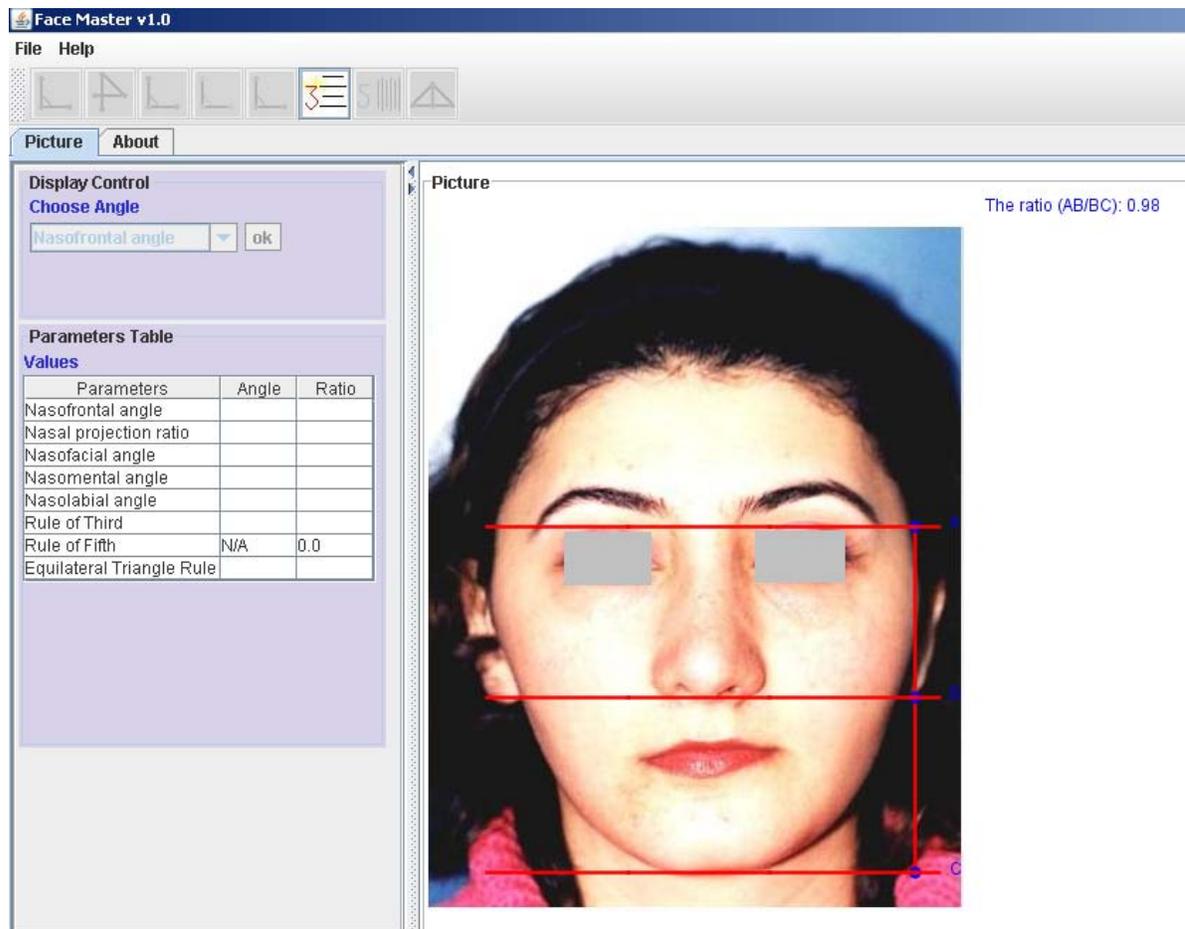


Fig. (5). Correct placement of the rule-of-the-third tool handles.

(4), the ratio is displayed instantaneously on the upper right side of the workspace.

2.6. Measurement of the Facial Thirds Method

One of the rules used in facial analyses is to see if the face is divided into vertical facial thirds in a balanced way. Ideally the distances between trichion-to-glabella, glabella-to-subnasale, and the subnasale-to-menton should be equal and if horizontal lines are drawn at trichion, glabella and menton, these lines should divide the face into three equal parts. In practice, the location of the trichion is found to be not very dependable since the hairline may recede, as the person gets older. Locating glabella in some patients is also troublesome. So an alternative method considers the lower two thirds of the face only and states that the ratio of the distance between nasion-to-subnasale and the distance between nasion-to-menton should be 47% to 53% [2]. So the ideal ratio should be $47/53=0.88$.

The software tool uses the ratio described in the alternate method for describing the facial thirds. The tool used for this purpose is called rule-of-the-third and there is a special icon in the icon tray. Frontal view or lateral view of the patient can be used for determination of this ratio. Upon clicking on the icon, three connected parallel lines appear on the workspace as shown in Fig. (5). Correct placement of the handles is shown in the where handle A is placed at the nasion, handle B at the subnasale, and handle C is placed at the menton.

2.7. Measurement of Horizontal Fifth Rule Method

Ideally, face should be divided into five equal parts by lines drawn at the edges of ears and eyes. This parameter is supposed to be indicative of this factor. A more practical alternative measurement indicative of this parameter is the division of intercanthal width to alar width [22]. The icon associated with this parameter is labeled as “the rule-of-fifth” in the toolbar area. The operation of the tool is shown in Fig. (6).

The handles labeled as EN are placed at the edges of the eyes as shown in Fig. (6), and the handles labeled as A are placed at the alar which defines the edge of the nose. The ratio is automatically displayed at the top corner of the workspace.

2.8. Nasal Base Triangle Measurement Method

Another photo view used in facial analyses is the base view of the nasal triangle. When viewed from below, the nasal base should form an equilateral triangle. To measure how much patient’s nose confirms to that, a parameter is devised which calculates the ratio of height to the base of the triangle. The icon that deals with this parameter is labeled as “equilateral triangle rule” and placed in the toolbar area. Upon clicking on the icon, an equilateral triangle is displayed on the workspace. The triangle needs to be placed

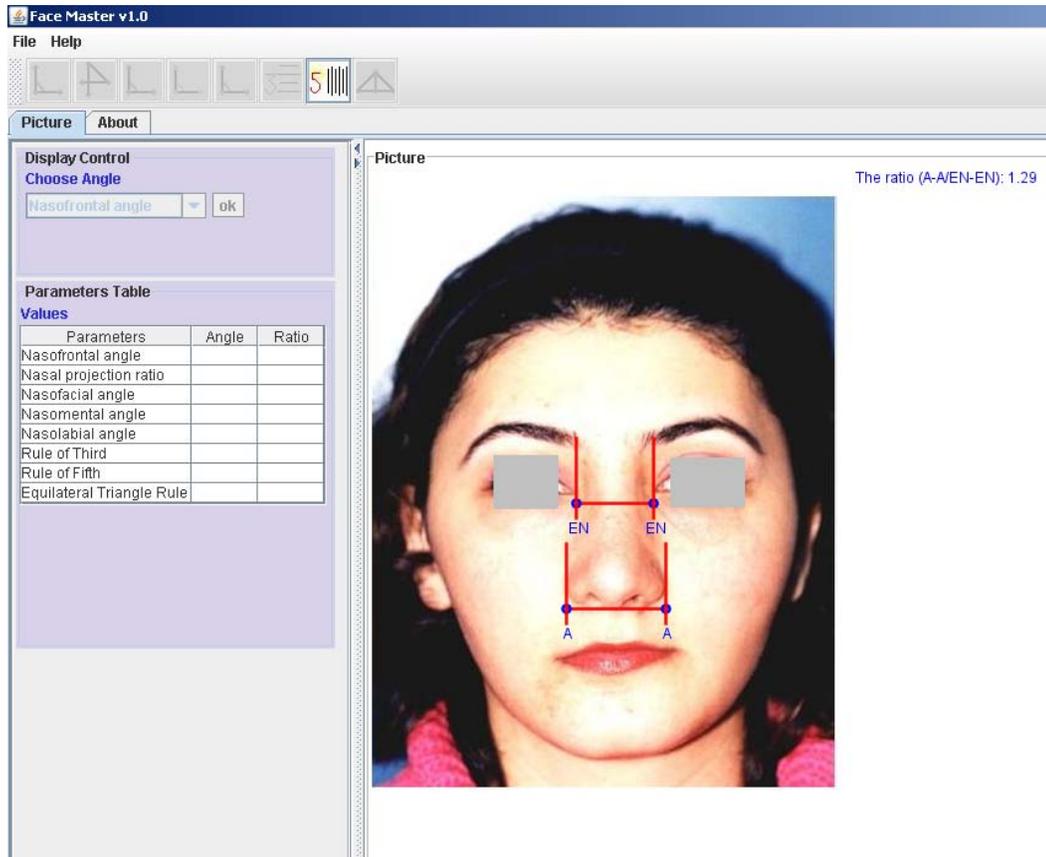


Fig. (6). Rule-of-the-fifth is displayed as a ratio of intercanthal width to alar width.

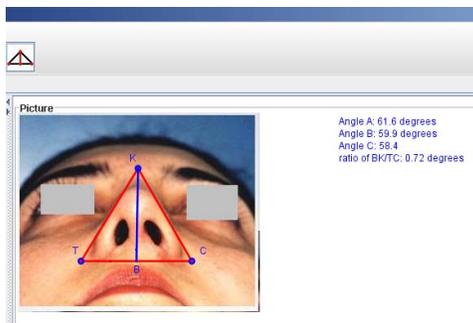


Fig. (7). Nasal base triangle placement over the basal base. over the nasal base confining the nose within the confines of the triangle. The ratio of BK to TC is the parameter that

describes the fitness of this parameter. Ideal value for this parameter is 0.86 which corresponds to a perfect equilateral triangle. Equilateral triangle rule is displayed in Fig. (7).

Handles B, K and C are dragged over the nasal view to confine the nasal triangle. The angles and ratio is displayed on the upper right corner.

3. RESULTS AND DISCUSSION

The software tool is designed to make measurements by ratios as a result; its accuracy is independent of the screen resolution or the aspect ratio of the screen. The measurements are also independent of camera resolution. The accuracy of the tool is tested by capturing photographs of a dis-

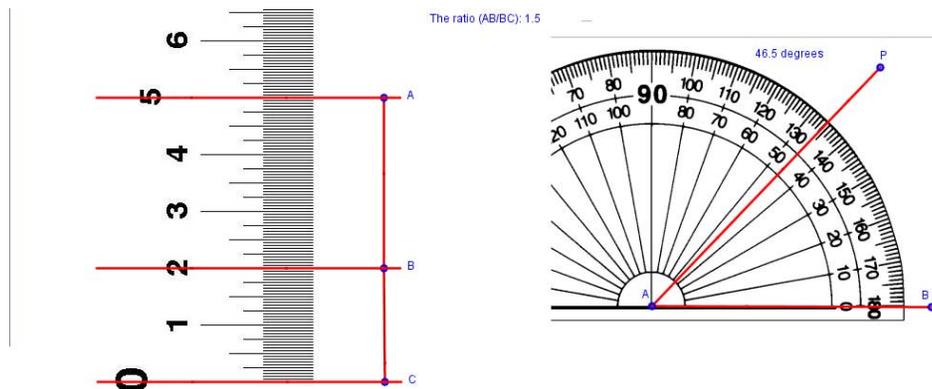


Fig. (8). Angle measurement is done with 0.1 degree accuracy.

played ruler and protractor with 1 mm resolution and measurements are done both by manually and by using software tool simultaneously. It is found that software tool calculated ratios and angles with accuracy up to 0.1 degree as it is shown in Fig. (8) (Maximum resolution of the ruler).

In case of nasal base triangle parameter measurement which is shown in Fig. (7), the angles of the triangle are displayed correctly however due to a software bug ratio display does not appear correct. Proper ratio should be calculated according to the following formula:

$$\frac{BK}{TC} = \frac{0.5}{\tan \frac{A}{2}}$$

where angle A is displayed on the upper right hand side of the workspace interactively. Angle A is indicated as K in the triangle displayed on the screen. Execution of the formula gives the correct BK/TC ratio.

In this study, we have introduced a license free software tool designed to aid the process of facial parameter measurement. Even though the software tool has eight specific measurement tools for extracting eight of the most frequently used facial parameters, the existing ratio and angular measurement tools can be easily adapted to measurement of any other parameter.

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