

# **Subadult Virtual Anthropology Database (SVAD)**

## **Data Collection Protocol:**

### **Dental Measurements on Virtual 3D Crania**

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This document presents the standardized protocol developed to collect deciduous and permanent odontometric data on 3D renderings of subadult crania obtained from computed tomography scans. This protocol was developed as part of National Institute of Justice Award 2019 DU-BX-0039. If the methodology presented herein is used or mentioned in a presentation or publication, then this document needs to be cited. Additionally, we strongly encourage all research using this protocol to be submitted to the Subadult Virtual Anthropology Database (SVAD) Zenodo Community to facilitate sharing and discovery of information (<https://zenodo.org/communities/svad/?page=1&size=20>).

#### **Data**

Four measurements taken on the left dental arcade of deciduous (10 teeth total) and permanent (14 teeth total, excluding third molars) teeth. The right antimeres can be substituted when necessary.

- Maximum mesiodistal crown diameter for all teeth (Sciulli 2001, Moorrees and Reed, 1954, Hillson et al 2005)
- Maximum buccolingual crown diameter for all teeth (Sciulli 2001, Moorrees and Reed, 1954, Hillson et al 2005)
- Mesiodistal cervical diameter for all teeth (Pilloud and Hillson, 2012; Hillson et al 2005)
- Buccolingual cervical diameter for all teeth (Pilloud and Hillson, 2012; Hillson et al 2005)

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## **Notes**

Measurements should be taken only if the tooth is erupted/erupting and shows at least initial root formation (Ri stage, AlQahtani et al. 2010).

Crown measurements are taken directly on the CT scans of individuals with the Amira™ measuring tool, whereas cervical measurements will be obtained by calculating the Euclidian distance between two landmarks placed in Amira™ as a vector norm in an excel spreadsheet.

All data can be recorded in Excel spreadsheets (.csv format) or and in a specific Access database (Dentabase) developed as part of National Institute of Justice Award 2017-DN-BX-0143.

## **Measurements of permanent teeth**

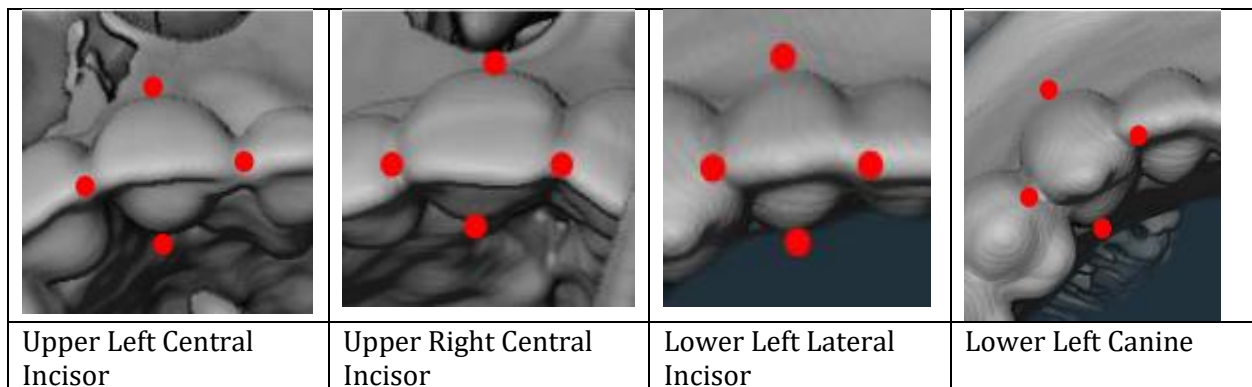
Permanent dentition is measured using a threshold range between **875-925 Hounsfield Units (HU)** (see **Data Collection in Amira™** section for more details).

### **Maximum Crown Diameters**

Crown diameter measurements are taken from the occlusal view of each tooth (Figs. 1 and 2). The user should take extra care to confirm the tooth in question is in the occlusal view before measuring. After placing the measurement, check the placement from several different views, but always return to an occlusal view before adjusting the measurement.

#### ***Maximum mesiodistal crown diameter of permanent teeth***

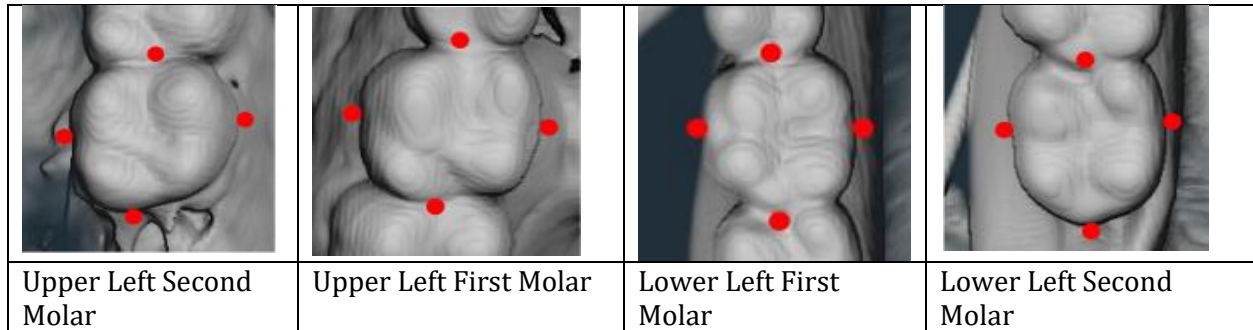
The largest mesial-to-distal dimension (the distance between the largest mesial and largest distal convexities), taken while viewing the occlusal surface.



*Fig. 1: Positioning of the permanent anterior teeth in the occlusal view in Amira™ with buccal, lingual, mesial, and distal points for crown measurements indicated by the red dots.*

### ***Maximum buccolingual crown diameter of permanent teeth***

When taking crown measurements on the teeth with sliding calipers, the maximum buccolingual measurement is taken perpendicular to the mesiodistal measurement. When placing landmarks in Amira™, this will not necessarily be the case. The landmarks are to be placed at the maximum buccal/labial and lingual/palatal expression of the crown (Figs. 1 and 2).



*Fig. 2: Positioning of the permanent posterior teeth in the occlusal view in Amira™ with buccal, lingual, mesial, and distal points for crown measurements indicated by the red dots.*

### **Cervical Diameters**

Landmarks for this measurement are placed at the cemento-enamel junction (CEJ) of the tooth, with care to still be on the enamel portion of the tooth (Figs. 3-7).



*Fig. 3: Positioning of the CEJ landmarks in Amira™ with buccal, lingual, mesial, and distal points indicated by the yellow lozenges for permanent cervical landmarks and the yellow spheres for the deciduous cervical landmarks.*

### ***Mesiodistal cervical diameter for permanent incisors and canines***

In anterior teeth, the cemento-enamel junction has a strong curve to occlusal on the mesial and distal sides, and this makes a natural measurement landmark at the most occlusal point of the curve (Fig. 4). The mesiodistal cervical diameter was therefore defined as the distance between the most occlusal points of the cemento-enamel junction curve on the mesial and distal sides.

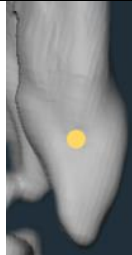
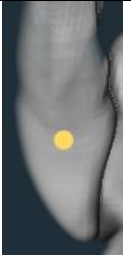
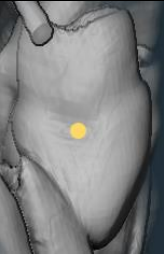
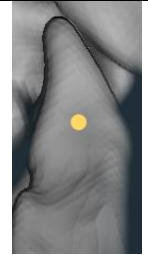
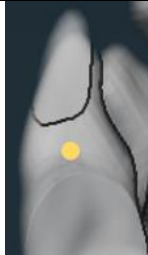
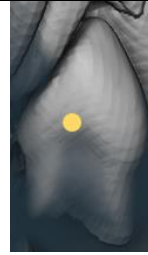

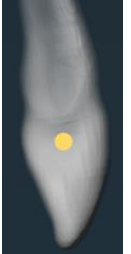
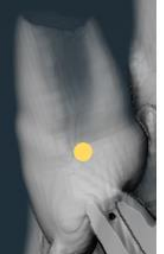
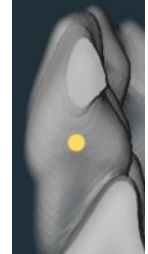
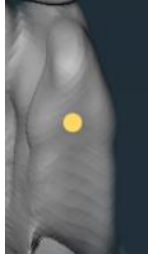

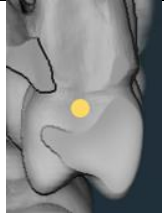

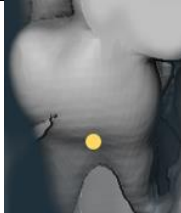
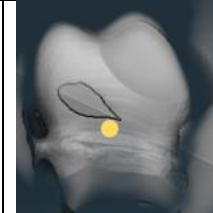
	Upper Left First Incisor	Upper Right Second Incisor	Upper Left Canine	Lower Left First Incisor	Lower Right Second Incisor	Lower Left Canine
Mesial						
Distal						

Fig. 4: Positioning of mesial and distal CEJ landmarks in Amira™ on permanent anterior teeth

### ***Mesiodistal cervical diameter for permanent premolars and molars***

The cemento-enamel junction on cheek/posterior teeth (*i.e.*, premolars and molars) does not have the same strong mesial and distal curve as in the anterior teeth. In the absence of naturally defined landmarks, the measurement point was therefore defined as midway along the cemento-enamel junction on the mesial and distal sides of the crown (Fig. 5). Normally, there is a broad concavity at this point that can guide placement.

	Upper Left Third Premolar	Upper Left First Molar	Lower Left Fourth Premolar	Lower Left Second Molar
Mesial				

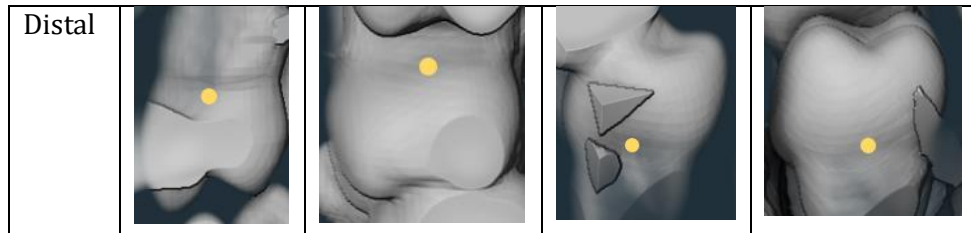


Fig. 5: Positioning of mesial and distal CEJ landmarks in Amira™ on permanent premolars and molars

### ***Buccolingual cervical diameter for permanent incisors and canines***

The cemento-enamel junction makes a single curve apically on the labial and lingual surfaces. This means that the buccolingual cervical diameter can be defined simply as the measurement at the cemento-enamel junction from labial to lingual at the most apical expression of the CEJ (Fig. 6). As these landmarks are not necessarily at equal levels, the axis of measurement may not be parallel to the occlusal plane.

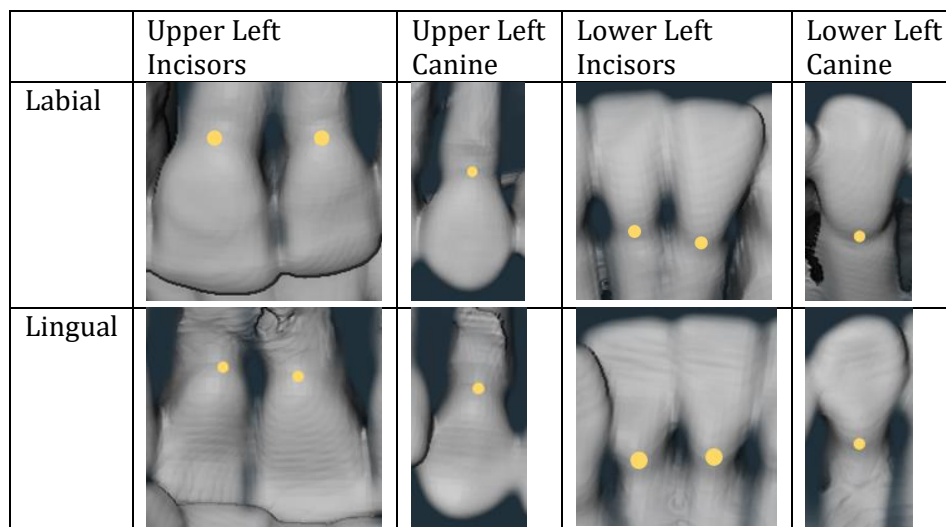
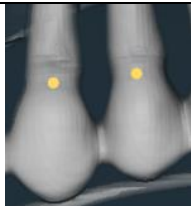
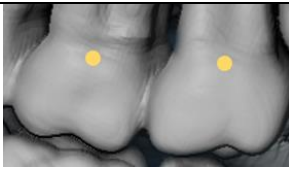
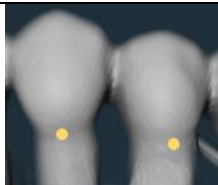

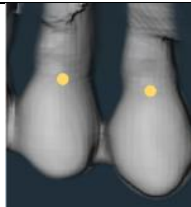
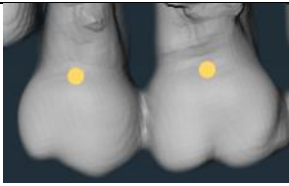
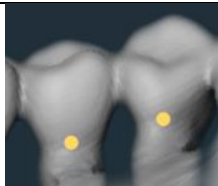
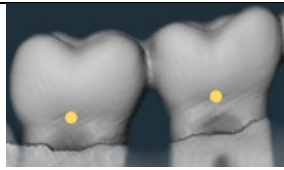


Fig. 6: Positioning of buccal and lingual CEJ landmarks in Amira™ on permanent anterior teeth.

### ***Buccolingual cervical diameter for permanent premolars and molars***

The cemento-enamel junction does not have a single apical or occlusal curve on the buccal and lingual sides of molars. Instead, the measurement is taken on the cervix at points midway along the buccal and lingual/palatal sides. In most upper molars, it is found that this point is the maximum bulge above the single lingual/palatal root. On the buccal side, there is usually a slight depression between the two buccal roots that serves as the

landmark. For lower molars, there is usually a slight depression on both the lingual and buccal sides between the two roots, at which the landmark is placed. Where there is a large enamel extension, the measurement is taken to one side or the other (Fig. 7).

	Upper Left Premolars	Upper Left First and Second Molars	Lower Left Premolars	Lower Left First and Second Molars
Buccal				
Lingual				

*Fig. 7: Positioning of buccal and lingual CEJ landmarks in Amira™ on permanent premolars and molars.*

## Measurements of deciduous teeth

Deciduous measurements will be viewed and taken within the threshold range of **575-625 HU** (see **Data Collection in Amira™** for more information).

### Maximum Crown Diameters

Crown diameter measurements are taken from the occlusal view of each tooth (Figs. 8 and 9). After placing the measurement, check the accuracy of the placement from several other views, but return to an occlusal view before making any necessary adjustments. Examples for anterior and posterior dentition are provided at the end of the definitions.

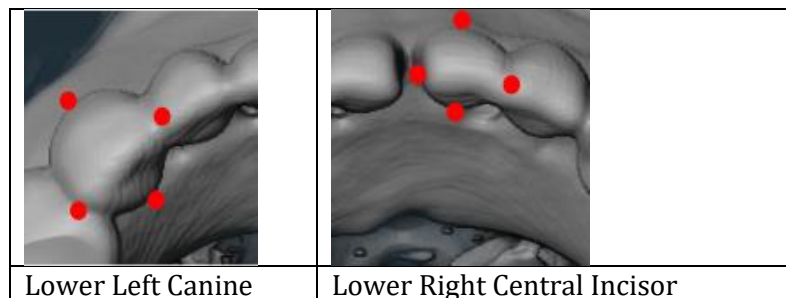
#### ***Maximum mesiodistal crown diameter of deciduous teeth***

The distance between the points of maximum curvature of the mesial and distal surfaces of the tooth (Figs. 8 and 9).

#### ***Maximum buccolingual crown diameter of deciduous teeth***

The distance between points of maximum curvature of the buccal and lingual surfaces of the tooth, as perpendicular to the mesiodistal measurement as possible in the occlusal view (Figs. 8 and 9). Although, again, landmark placement will not necessarily be perpendicular.

**This measurement will not be taken for the lower third deciduous premolar or the upper third deciduous premolar, as the tubercle of Zuckerkandl made placement difficult leading to higher observer error.**



*Fig. 8: Positioning of the deciduous anterior teeth in the occlusal view in Amira™ with buccal, lingual, mesial, and distal points for crown measurements indicated by the red dots.*



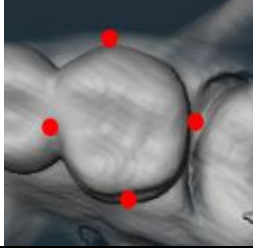
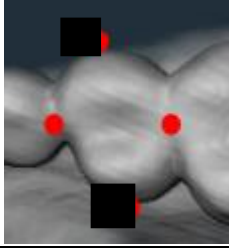
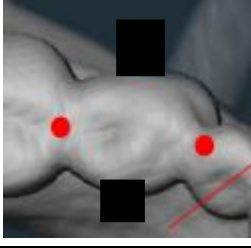
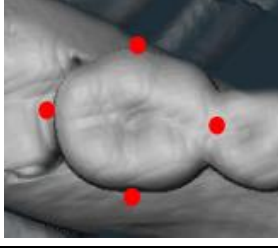
			
Upper Left Fourth Premolar (Second Molar)	Upper Left Third Premolar (First Molar)	Lower Left Third Premolar (First Molar)	Lower Left Fourth Premolar (First Molar)

Fig. 9: Positioning of the deciduous posterior teeth in the occlusal view in Amira™ with buccal, lingual, mesial, and distal points for crown measurements indicated by the red dots.

## **Cervical Diameters**

### ***Mesiodistal cervical diameter of deciduous incisors and canines***

The points are placed at the most occlusal curvature on the cemento-enamel junction on the mesial and distal sides of the tooth (Fig. 10).

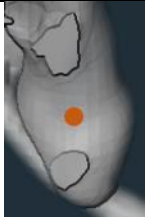

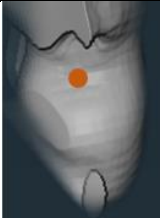

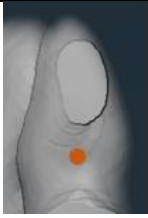

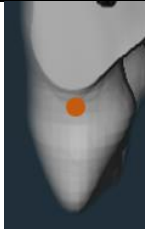
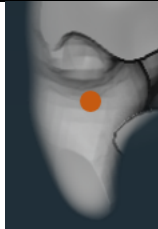




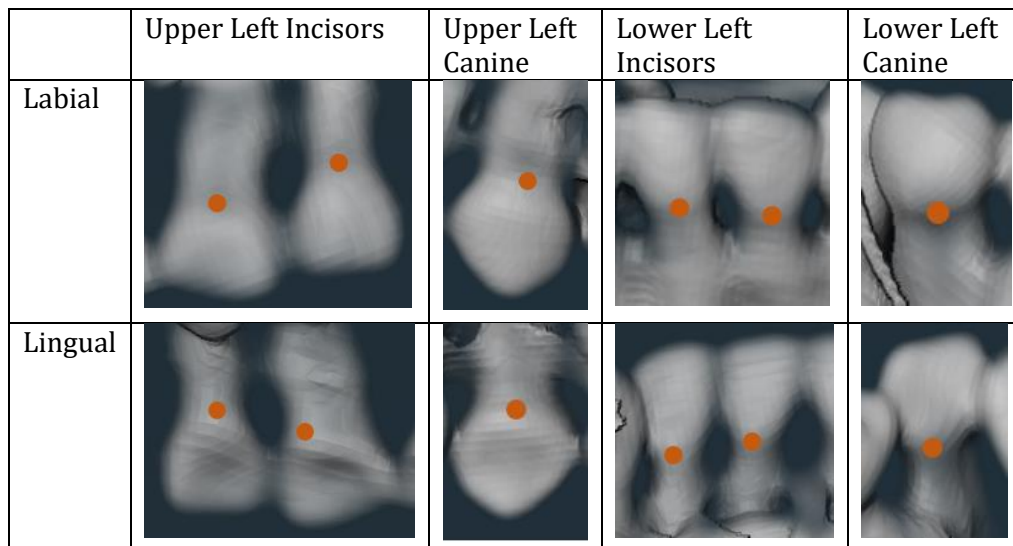
	Upper Left First Incisor	Upper Left Second Incisor	Upper Left Canine	Lower Left/Right First Incisors	Lower Left Second Incisor	Lower Left Canine
Mesial						
Distal						

Fig. 10: Positioning of mesial and distal CEJ landmarks in Amira™ on deciduous anterior teeth.

### ***Labiolingual cervical diameter of deciduous incisors and canines***

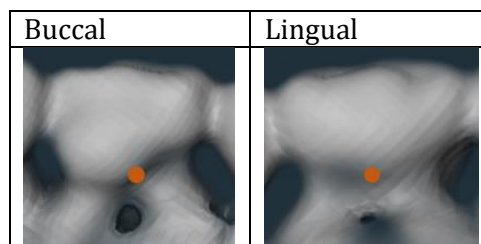
The measurements are taken between the most apical point on the curve of the cemento-enamel junction on the buccal and lingual sides at the CEJ (Fig. 11).



*Fig. 11: Positioning of buccal and lingual CEJ landmarks in Amira™ on deciduous anterior teeth.*

### ***Buccolingual cervical diameter of deciduous mandibular third premolar***

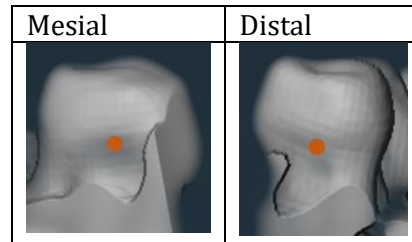
Distance between the midpoints of the buccal and lingual sides— midpoint being defined by the division of the mesial and distal roots (Fig. 12). On the buccal side, this point is distal to the cingulum bulge on the mesiobuccal aspect of the crown. There is also a slight occlusal curve in the CEJ at this point.



*Fig. 12: Positioning of buccal and lingual CEJ landmarks in Amira™ on the deciduous mandibular third premolar.*

### ***Mesiodistal cervical diameter of deciduous mandibular third premolar***

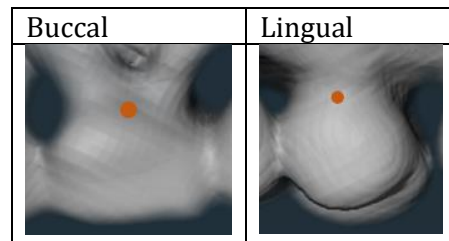
This measurement is taken between the midpoints of the cemento-enamel junction on the mesial and distal sides of the tooth (Fig.13). On the mesial aspect there is a slight curve to occlusal, so one landmark is placed here at the most occlusal point on the CEJ. On the distal surface, the midpoint is generally associated with a slight depression that extends down the length of the distal root.



*Fig. 13: Positioning of mesial and distal CEJ landmarks in Amira™ on the deciduous mandibular third premolar.*

### ***Buccolingual cervical diameter of deciduous maxillary third premolar***

One point is placed at the midpoint of the cervical crown margin on the buccal side as defined by the division of the two buccal roots (Fig. 14). This point is just distal to the bulge on the cingulum on the mesiobuccal aspect of the crown. On the lingual side, the point is placed at the maximum bulge of the lingual root.



*Fig. 14: Positioning of buccal and lingual CEJ landmarks in Amira™ on the deciduous maxillary third premolar.*

### ***Mesiodistal cervical diameter of deciduous maxillary third premolar***

This measurement is taken between the midpoints of the cervical crown margin on the mesial and distal sides (Fig. 15). The midpoint on the distal side is defined by the division between the distobuccal and lingual roots. On the mesial side the midpoint is defined at the most occlusal curve of the CEJ.

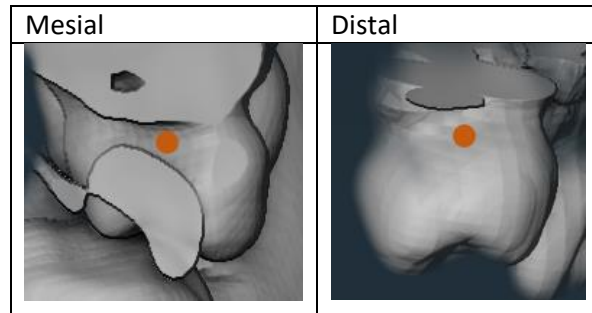


Fig. 15: Positioning of mesial and distal CEJ landmarks in Amira™ on the deciduous maxillary third premolar.

### ***Buccolingual cervical diameter of deciduous mandibular fourth premolar***

This measurement is taken between the midpoints of the cervical crown margin on the buccal and lingual sides (Fig.16). The midpoint is defined on both sides by the division between the mesial and distal roots.

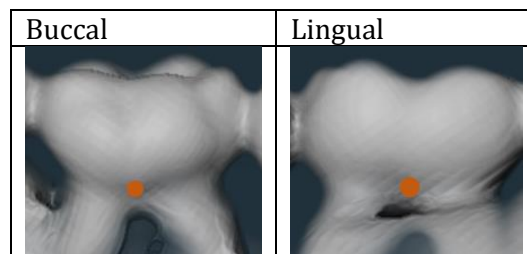


Fig. 16: Positioning of buccal and lingual CEJ landmarks in Amira™ on the deciduous mandibular fourth premolar.

### ***Mesiodistal cervical diameter of deciduous mandibular fourth premolar***

This measurement is taken from the midpoint of the cervical crown margin on the mesial and distal sides (Fig.17). On both sides there is generally a groove extending through the length of the root that marks the midpoint. Often, this groove is more pronounced on the mesial side.

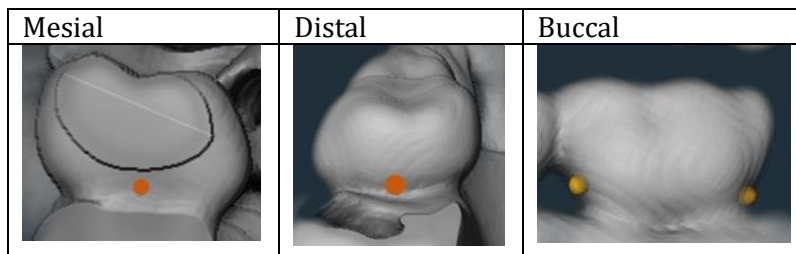
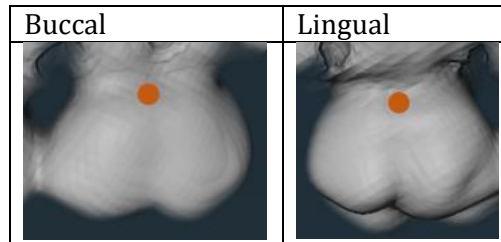


Fig. 17: Positioning of mesial and distal CEJ landmarks in Amira™ on the deciduous mandibular fourth premolar.

### ***Buccolingual cervical diameter of deciduous maxillary fourth premolar***

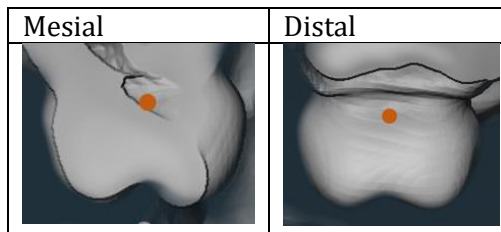
The midpoint of the buccal aspect is defined by the division of the two buccal roots. The lingual aspect is defined at the most prominent bulge of the lingual root (Fig. 18).



*Fig. 18: Positioning of buccal and lingual CEJ landmarks in Amira™ on the deciduous maxillary fourth premolar.*

### ***Mesiodistal cervical diameter of deciduous maxillary fourth premolar***

This measurement is taken between the midpoint of the cervical crown margin on the mesial and distal crown sides (Fig. 19). The midpoint is defined distally as the division between the distobuccal and lingual roots. Mesially, this point is at the most occlusal curve of the CEJ.





*Fig. 19: Positioning of mesial and lingual CEJ landmarks in Amira™ on the deciduous maxillary fourth premolar.*

# Data collection in Amira™

## 1. Opening Amira™.

Click on the “**Project**” tab to open a workspace. Before selecting anything else, click the perspective button. The button is located in a bar of other buttons just above the viewing panes and looks like

an eye:  Clicking the button will change the symbol in front of the eye to parallel lines: . Use the parallel line setting for all specimen editing and measuring. ***You have to reset this every time you reopen Amira™.***

Choose [*Open Data...*] (button in the “**Project View**” pane in the upper left corner).

## 2. Loading a stack of CT scans.

Find the individual you are interested in and select all of the DICOMs in that folder (*Nota Bene*: not the DICOM directory). **Click [Open]**.

If you get a warning about the file size being too large, choose the radio button for “Load complete volume into memory” and **click [OK]**.

A dialog box called “DICOM Loader” will prompt you to check the parameters of the DICOM stack. Scroll through the window and if everything looks good (numbering not out of order, no gaps in the data, etc.), **click [OK]**. Any errors will be shown as red numbers in the list of DICOMs. If that is the case, only select the DICOM files that appear in black by pressing shift and clicking on the first and last DICOM of the stack that you want to open.

## 3. Navigating through the slices

The file should appear as a lozenge in the “**Project View**” pane. *With this lozenge selected, select the orange Orthoslice tab* in the Project View pane. If it is not present in that pane, right click on the lozenge, *select Display->Ortho Slice* and **click on [Create]**. The CT slice should appear in the viewing console on the right. You can change the plane of the slice view by *selecting xy, xz, or yz in the console header*. If the hand (**Trackball tool**) is selected in that header, you can use it to move the set around. You can also scroll through the slices by clicking the box next to the **Slice Number** line in the “**Properties**” pane and using the mouse to scroll, or by moving the cursor between the two triangles.

## 4. Extracting skeletal and dental structures

*Select the green lozenge. Click on the yellow [Volume Rendering] button* in the “**Project View**” pane, or right click on the green lozenge, *select Display->Volume Rendering* and click **[Create]**. A 3D rendering of the entire scanned area of the body should appear in the viewing console on the right. You can use the mouse on hand mode to turn the body around at different angles.

**Click on the yellow [Volume Rendering] lozenge.** In the “**Properties**” pane, click on the triangle in the middle or the left of the Colormap setting and move it to adjust the threshold of the greyscale values (also called masking value) and filter out the structures that you don’t want to see (mainly

soft tissue, clothes, and medical materials). The higher you go, the denser tissues you will have left visible. You can also type a value in the box. Values should be between **875-925 Hounsfield Units** when measuring permanent teeth and between **575-625 Hounsfield Units** when measuring deciduous teeth. If you cannot see the teeth, you can move the body around and/or unselect the little orange (Amira™ v. 2019) or blue (Amira™ v. 2020) box in the [**Orthoslice**] lozenge to hide the CT slice.

## 5. Final visualization steps

Once the masking values are within the specified range, select the orange [**Orthoslice**] lozenge to make it active, as you will be using it to help you take measurements or place landmarks. Don't forget that you can move the 3D image by clicking it with the hand option selected and moving the mouse around.

You can also use the magnifying glass button and crossed arrows to navigate the structure around.

If you need to hide some parts of the body to facilitate scoring (like lower jaw, vertebrae, ribs, adjacent teeth, etc.), select the [**Orthoslice**] lozenge. In the "**Properties**" pane, **click on the Clipping Tool**, an icon in the upper right corner of that pane that looks like a cube with a green line crossing it. Click on it once to hide half of the body, click on it again to see the full structure and click on it a third time to see the other half of the structure. You can do this in every plane, by changing the plane in the Orientation line and in the viewing console. You can navigate through the partial views by clicking on the arrow of the "**Slice Number**" line in the "**Properties**" pane, keeping the [**Orthoslice**] lozenge selected, and moving it left or right. Note: you can add multiple orthoslice lozenges (step 3 above) so that each one controls movement through a different plane.

## 6. Placing landmarks (for cervical diameters)

**Landmarks will be placed in the following order:** all buccal, then all lingual, then all distal, then all mesial.

Within those categories, do posterior to anterior teeth, for maxillary then mandibular. Start with UM2 buccal, then UM1 buccal etc. to U11 buccal; then LM2 buccal, LM1 buccal etc. to L11 buccal; then UM2 lingual, UM1 lingual etc. to L11 lingual; then UM2 distal, UM1 distal etc. to L11 distal; then UM2 mesial, then UM1 mesial etc. to L11 mesial.

The same order applies for deciduous CEJ landmarks.

Permanent and deciduous dentition are separate landmark files – if there is mixed dentition, place all landmarks for deciduous teeth and save them as a single object then create a new landmarks object to place and save all permanent landmarks.

Above the "**Project**" pane, go to *Project -> Create Object -> Points and Lines -> Landmarks -> Create*. A new green lozenge called [**Landmarks**] will appear. Select it, then go to the "**Properties**" pane below and select the [**Volume rendering**] you have for Image Set1. **Click on the little icon with the red or white flag** in that same pane. A yellow lozenge called [**Landmark View**] will appear. If you need to adjust landmark size, *select the yellow [Landmarks View] lozenge* and change the size in the "**Properties**" pane using the cursor.

If not already selected, *select the green [Landmarks] lozenge*. Make sure the **Edit mode** in the **“Properties”** pane is set to **“Add”**. With the hand icon selected in the right pane where the segmented surface is, move the cranium until it is in the right position to place a landmark. Select the cursor (mouse arrow) at the top of that same pane to place landmarks. Click on the area of the tooth where you want to place the landmark.

### **Notes and comments on landmark placement:**

***Be sure to always place landmarks in the same order***, it makes things easier when you export the coordinates into Excel afterwards.

If you need to change the position of the landmark, make sure *the green [Landmarks] lozenge is selected and change [Edit Mode] to “Move”*. Make sure the cursor is selected at the top of the right **“Viewing”** pane. Click on the landmark you want to move and click the new spot where you want to move it. If you are unable to select a landmark, try clicking on different areas of the landmark and/or from different views until clicking on the landmark makes it active (box next to Marker Type becomes white instead of gray). You can move it as many times as you want.

Make sure the **[Landmark] lozenge is selected** in the **“Properties”** pane by clicking on it. To add a new landmark, **change the Edit Mode to “Add”** and click on the tooth to add it.

Alternate between the hand to move the structure around and the arrow to place landmarks. You cannot place landmarks if the hand is selected.

***IF YOU CANNOT PLACE A LANDMARK AT ITS CORRECT LOCATION ON A TOOTH, DO NOT SKIP THE LANDMARK.*** Instead, place it in an area of the CT scan that is far enough from the jaw so as not to be considered as a misplacement. Group all “unplaceable” landmarks in that same area. They will be easier to spot in the exported file.

## **7. Taking measurements (for crown diameters)**

Make sure the masking values (**Colormap** under the **[Volume rendering]** lozenge) are within the proper value ranges for permanent and deciduous dentition provided above.

**Click on [View] above the “Project View”** pane and select **“Measuring”** (alternatively, go to the top of the viewing console on the right, click on the dropdown next to the small ruler, and select **“3D Length”**). A yellow **[Measurement]** lozenge will appear.

**Click on it** so it appears in the **“Properties”** pane. Next to “Add,” make sure the box to the left of “3D” is checked and select **[Line]** next to the 3D box. When moving to the **“Viewing”** pane, your cursor should now be an arrow with a capital M. Take your measurement in the “Viewing” pane on the right by clicking once to create its start and once to create its end points. It should appear as a line with two red dots and show its numerical value in the **“Properties”** pane.

If you wish to move one or either of these points to adjust your measurement, make sure it is still highlighted in the **“Properties”** pane. Then **click on one of the red points** and drag it to its new location.



NB: once a measurement is taken, select the hand icon in the viewing pane on the right and give your object a turn to check that the measurement is in fact correct and not just a 2D projection of your 3D measurement. If it is not, **click on the arrow at the top of the “Viewing” pane** and change either one or both points by clicking on them and then clicking on the part where you want your measurement point to be. Make sure you are in an occlusal view when making necessary adjustments.

Once you are satisfied with your measurement, **click on the small lock symbol** next to your measurement in the “**Properties**” pane. This will “lock” your measurement and ensure it cannot be accidentally modified while you are manipulating other measurements, as they can cross each other.

You also have the option of hiding the measurement by clicking the eye icon next to the measurement in the “**Properties**” pane for a clearer view when placing other measurements.

You can then take as many other measurements as you want by simply **clicking the small ruler icon in the “Viewing” pane** using the measurement tool while the [Measurement] lozenge is selected. This will automatically create a new measurement.

Alternatively, **click on “Line”** in the “**Properties**” pane while the [Measurement] lozenge is selected to create a new measurement.

Repeat these steps until all your measurements are done. *The following order can be adopted for measurements:*

- Work from the most posterior teeth to the most anterior teeth (M2 to central Incisors) for the maxilla then mandible
- Measurement order per tooth: maximum mesio-distal crown diameter (MD) then maximum bucco-lingual crown diameter (BL)
- The final order will be: UM2\_MD -> UM2\_BL -> UM1\_MD -> UM1\_BL, etc.
- Then do the same thing for lower teeth starting with M2
- For deciduous teeth, work the same way: up4\_md > up4\_bl > up3\_md > uc\_md > uc\_bl > ui2\_md > ui2\_bl > ui1\_md > ui1\_bl then the same for the lower teeth. **BL crown diameter shall not be taken for up3 or lp3.**
- If there is a measurement that you cannot take, add an obviously fake measurement (~ 0mm or 50 mm) anywhere on the scan so that it doesn't mess up the measurement order when exporting.

## 8. Saving the project and data

### a. For measurements:

Select the [Measurement] lozenge. In the bottom right of the “**Properties**” pane, select “**Export.**” A lozenge called [Measurement.Spreadsheet\*] will appear in the “**Project View**” pane. Select this lozenge, then choose **File -> Export Data As** and save as a CSV file named “**identifier\_xxx\_odontometrics\_crown\_permanent**” for example in the corresponding individual's folder. The same thing should be done for deciduous measurements, under the name “**identifier\_xxx\_odontometrics\_crown\_deciduous**”.

Open the CSV file you just created, highlight all the values under the column named “**Values,**” and copy them. In a separate excel spreadsheet named “**odontometrics\_crown\_permanent\_xxx\_yyy**” or “**odontometrics\_crown\_deciduous\_xxx\_yyy**” highlight the cells where the values will be pasted. Right click and choose “**Transpose**” under “**Paste Options**” (this allows the values to be pasted in a single row even though they were copied from a single column). Change all of the “fake” measurements to NA.

Every week, make a copy of the previous week’s spreadsheet and work from that copy. You should go from “**odontometrics\_crown\_permanent\_xxx\_yyy**” to “**odontometrics\_crown\_permanent\_xxx\_zzz**” as you progress so in the end, you have a spreadsheet with all the data and several backup copies to prevent data loss.

**b. For landmarks:**

Once you are happy with your first few landmark positions, *go to File-> Save As* and save the landmarks as “**identifier\_xxx\_permanent/deciduous\_landmarks**” in .ascii format in the CT folder of the corresponding individual.

**Save this “Landmarks” object regularly as you are placing new ones, in case Amira™ crashes. To do this, go to File-> Save data after every few landmarks. This will automatically update the file you initially saved.**

To do deciduous teeth and permanent teeth separately, create two landmark files and save them as “**identifier\_yyy\_deciduous\_landmarks**” and “**identifier\_yyy\_permanent\_landmarks**”, both in .ascii format in the same folder.

By clicking the little orange (Amira™ v. 2019) or blue (Amira™ v. 2020) box in the [Landmarks] lozenge, you can hide it before creating another landmarks file to work on the second set (*e.g.*, the deciduous landmarks).

# Saving the data in a csv/excel spreadsheet and in RDS format

## 1. Transposing the landmark coordinates into a csv spreadsheet

Download the template file named “**SVAD\_Permanent\_Cej\_Landmarks.csv**” or “**SVAD\_Deciduous\_Cej\_Landmarks.csv**” from the SVAD webpage (<https://www.unr.edu/anthropology/research-and-facilities/subadult-database>) and open it with the Excel application.

These files are organized as follows:

- Column one holds the identifier number, *i.e.*, the individual that landmark data were collected for. By default, the template will have xxx and yyy as two exemplary identifiers. These identifiers are repeated (56 times for permanent CEJ landmarks, 40 times for deciduous CEJ landmarks), one for each of the CEJ landmarks collected.
- Column two holds the names of the CEJ landmarks indicating which tooth they belong to (e.g., UP4/up4, or LI1/li1) and their location on the CEJ (B/b = buccal, L/l = lingual, M/m = mesial, D/d = distal). There should be as many lines as there are landmarks for each individual, repeated for every individual.
- Columns three to five hold the 3D coordinates (x,y,z) of each landmark (x in column three, y in column four, and z in column five).

## 2. Adding the landmark data to the csv spreadsheet

Locate the “**identifier\_xxx\_permanent/deciduous\_landmarks**” file for the individual the landmark data was collected.

Right click on that file and open it using the Notepad application. It should show the x, y and z coordinate sets for each landmark grouped in the correct order.

If necessary, adjust the window to visualize the coordinates in three columns in Notepad so you have one landmark per row (there should be a total of 48 rows here) and the coordinates start below the @1 symbol (see figure below).

Highlight/select the x,y,z coordinates of all landmarks, as visualized below.

```
# Avizo 3D ASCII 3.0

define Markers 56

Parameters {
  NumSets 1,
  ContentType "LandmarkSet"
}

Markers { float[3] Coordinates } @1

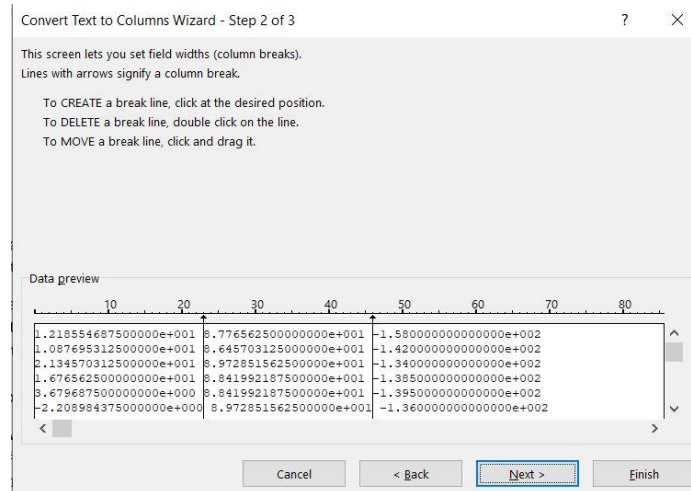
# Data section follows
@1
1.116011047363281e+001 8.630563354492188e+001 -2.090000000000000e+002
8.195266723632813e+000 7.839938354492188e+001 -2.125000000000000e+002
4.242141723632813e+000 7.049313354492188e+001 -2.140000000000000e+002
1.277297973632813e+000 6.456344604492188e+001 -2.140000000000000e+002
-2.675827026367188e+000 5.863375854492188e+001 -2.115000000000000e+002
-1.058207702636719e+001 5.566891479492188e+001 -2.130000000000000e+002
-1.651176452636719e+001 5.072750854492188e+001 -2.130000000000000e+002
1.017182922363281e+001 9.223532104492188e+001 -2.285000000000000e+002
6.218704223632813e+000 8.136422729492188e+001 -2.340000000000000e+002
2.890167236328125e-001 7.148141479492188e+001 -2.365000000000000e+002
-1.687545776367188e+000 6.654000854492188e+001 -2.385000000000000e+002
-8.605514526367188e+000 6.061032104492188e+001 -2.420000000000000e+002
-1.354692077636719e+001 5.863375854492188e+001 -2.405000000000000e+002
-1.947660827636719e+001 5.764547729492188e+001 -2.410000000000000e+002
1.277297973632813e+000 9.124703979492188e+001 -2.100000000000000e+002
-6.992645263671875e-001 8.235250854492188e+001 -2.130000000000000e+002
-3.664108276367188e+000 7.444625854492188e+001 -2.135000000000000e+002
-6.628952026367188e+000 6.851657104492188e+001 -2.145000000000000e+002
-8.605514526367188e+000 6.258688354492188e+001 -2.140000000000000e+002
```

Press ctrl+C to copy and ctrl+V to paste the coordinates in the x column of the csv spreadsheet. This should fill the x column for the entire set of landmarks of that identifier. Confirm there are the same number of rows as landmarks, the same identifier in column one, landmark abbreviations in column two, and landmark coordinate values in column three.

	A	B	C	D	E	F	G	H	I	J
1	identifier	landmark	x	y	z					
2	xxx	UM2_B	1.116011047363281e+001	8.630563354492188e+001	-2.090000000000000e+002					
3	xxx	UM1_B	8.195266723632813e+000	7.839938354492188e+001	-2.125000000000000e+002					
4	xxx	UP4_B	4.242141723632813e+000	7.049313354492188e+001	-2.140000000000000e+002					
5	xxx	UP3_B	1.277297973632813e+000	6.456344604492188e+001	-2.140000000000000e+002					
6	xxx	UC_B	-2.675827026367188e+000	5.863375854492188e+001	-2.115000000000000e+002					
7	xxx	UI2_B	-1.058207702636719e+001	5.566891479492188e+001	-2.130000000000000e+002					
8	xxx	UI1_B	-1.651176452636719e+001	5.072750854492188e+001	-2.130000000000000e+002					
9	xxx	LM2_B	1.017182922363281e+001	9.223532104492188e+001	-2.285000000000000e+002					
10	xxx	LM1_B	6.218704223632813e+000	8.136422729492188e+001	-2.340000000000000e+002					
11	xxx	LP4_B	2.890167236328125e-001	7.148141479492188e+001	-2.365000000000000e+002					
12	xxx	LP3_B	-1.687545776367188e+000	6.654000854492188e+001	-2.385000000000000e+002					
13	xxx	LC_B	-8.605514526367188e+000	6.061032104492188e+001	-2.420000000000000e+002					
14	xxx	LI2_B	-1.354692077636719e+001	5.863375854492188e+001	-2.405000000000000e+002					
15	xxx	LI1_B	-1.947660827636719e+001	5.764547729492188e+001	-2.410000000000000e+002					
16	xxx	UM2_L	1.277297973632813e+000	9.124703979492188e+001	-2.100000000000000e+002					
17	xxx	UM1_L	-6.992645263671875e-001	8.235250854492188e+001	-2.130000000000000e+002					
18	xxx	UP4_L	-3.664108276367188e+000	7.444625854492188e+001	-2.135000000000000e+002					
19	xxx	UP3_L	-6.628952026367188e+000	6.851657104492188e+001	-2.145000000000000e+002					
20	xxx	UC_L	-8.605514526367188e+000	6.258688354492188e+001	-2.140000000000000e+002					

While the values are still selected in Excel, go to **Data > Data tools** and click on **“Text to Columns”**. Make sure the option checked is **“Fixed width”**, then click **“Next”**.

Excel should have automatically identified the break line between the values as shown by lines running through the data, effectively separating x, y, and z values. If not, directly click where the break lines should be to separate all three values for the x,y,z coordinates.



Make sure the lines are placed correctly (*i.e.*, not cutting through any numbers that shouldn't be separated). When you have confirmed it is correct, click **"Next"** and then **"Finish"**. Your x, y, z data should now be separated into columns three to five.

Check that all rows corresponding to the identifier (one row per landmark) are filled. If stars (\*\*\*) or octothorpes (###) appear instead of the values, do not worry. If you select a cell, the correct values will appear in the fx bar.

### 3. Missing landmark coordinates

Since you placed the NA landmarks in the same spot in Amira, their coordinates should be relatively similar (x,y, and/or z). You will have to manually replace missing landmark coordinates in the spreadsheet by writing NA for the x,y,z values as needed.

Repeat steps 2 and 3 for each individual/identifier you wish to add to the dataset. Remember to update the name of the spreadsheet with each identifier that is added to it (*e.g.*, **"projectname\_typeofdata\_identifier\_xxx\_yyy"**) and save it regularly as you fill it in.

### 4. Saving the csv file in RDS format

Because csv files can be easily corrupted, it is recommended to save each csv file on a regular basis into RDS format.

To do this, open RStudio and run the following code:

```
library(tidyr)
library(dplyr)
library(readr)
library(base)
```

- If you haven't installed these packages before, please do so prior by running the code:  
install.packages("package\_name")

#Load old csv file and save it as a RDS file

```
File_name <- read_csv("~/path/to/database/File_name.csv")
```

```
write_rds(File_name, "~/path/ to/database/File_name.rds", row.names=FALSE)
```

- The new RDS file will be automatically created in that location (following the path you wrote).

**Create a copy of the csv file prior to additional data collection and collect in the new copy.**

Update the last identifier number every time you modify it (*i.e.*,

**"projectname\_typeofdata\_identifier\_xxx\_yyy"** to

**"projectname\_typeofdata\_identifier\_xxx\_zzz"**). That way, data is added on a regular/weekly basis and if something happens to the file, you can always revert to the previous one as a backup. You will then save each new weekly csv file as a RDS file so you have backups in RDS formats.

## References

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