Summary

5.1   A skeletal structure is built in Maya using joint hierarchies.

5.2   Bones are visual connections from one joint to the next but do not physically exist in the Maya scene file.

5.3   The main proportions of the character geometry should be in place before beginning the skeletal structure.

5.4   If a character is made of polygons, it is important not to smooth the geometry at this point, as it adds unnecessary problems later in the skinning process.

5.5   A character's skeletal structure should be based on reality. Research is crucial for proper motion. Sometimes it is necessary to combine skeletal structures from multiple animals in order to create a skeleton that works for your character.

5.6   Each appendage should be considered as a separate control system, so separate joint chains should be created for each leg, arm, finger, torso, head, ears, or tails.

5.7   File referencing is a tool that can be used to expedite workflow. File referencing provides the ability to overlap areas of the production pipeline.

5.8   Files that are referenced into another scene file are not physically part of current scene. Instead, a path is made that points to the referenced scene file so that Maya can display it.

5.9   When using file referencing, make sure to utilize the name clash options so that multiple nodes with the same name are not confused.

5.10   Files that are referenced can be removed, replaced, or even imported into the current scene file.

5.11   Remember that when your character is facing you, his left side is your right side. This is important so that you label left and right sides correctly.

5.12   Make sure to always open the tool option box to reset the tool before using it for the first time every day.

5.13   Geometry should be placed on its own layer so that it can be referenced. This makes it more difficult to accidentally select the geometry, making it easier to work with joints.

5.14   Using X-Ray Joints in the shading options of each view panel provides the ability to see the joints through your geometry.

5.15   Joints can only be created on a grid, and for this reason, joints are placed only in orthographic view panels.

5.16   Joints can be displayed at different sizes without affecting their functionality.

5.17   Maya uses a right-handed Cartesian coordinate system in order to define the position of objects in world space, where the X axis points left to right, the Y axis points up and down, and the Z axis points forward and backward.

5.18   Object space is a coordinate system based on the translation and rotation of a particular object. Each object exists in its own object space.

5.19   Local space is a coordinate system that determines an object's position based on its position and how it relates to the position of its parent.

5.20 Local rotation axis is a separate coordinate system that applies to joints. The local rotation axis of a joint is determined by the position of its child.

5.21 The default setting of the local rotation axis is XYZ, where X points to the child joint and Y points in an upward direction.

5.22 The local rotation axis for joints being controlled by an IK chain must have X pointing toward the child.

5.23 The local rotation axis for joints being controlled by FK must have the local rotation axis matching closely to world space.

5.24 You can display the local rotational axes in object mode or component mode.

5.25 If a mistake is made when positioning joints, simply undo the mistake and continue with the placement.

5.26 Joints can be moved, rotated, or scaled into place. If rotated or scaled, joint transformations must be frozen. If moved, joint orientation must be reoriented.

5.27 A warning sign is displayed when reorienting if a joint's rotations are not frozen at zero.

5.28 Manual rotation of the local rotational axis must sometimes occur. This can be accomplished in component mode using the rotate tool.

5.29 The following MEL command can be used for precise rotations of the local rotation axis: rotate -r -os 0 180 0.

Assignments: Joint Placement in a Character

! Remember, your body is your best reference for joint placement. If you are unsure where a joint should be placed, stand in front of a mirror for observation and put your hand on the area in question to feel how your skeleton moves.

Assignment 5.1: Creating a Spine, Neck, and Head Skeleton

Set up your work environment by doing the following:

1. Open Maya and set your project.
   a. From your computer's desktop, go to [**Start > Programs**] and select Maya.
   b. Once Maya is open go to [**File > Project > Set…**] and browse to your project folder then click **OK**.

2. Create a reference to your last saved file:
   a. Go to [**File > Create Reference**] and select *04_asgn02.ma*. This will insure that your model will be updated easily if you are still working on modeling, texturing, or blend shapes.

3. Set all four view panels to **X-Ray Joints** mode. This will allow you to see your joints easily and still be able to see the volume of your geometry.
   a. In the top, front, side, and perspective view panels, go to [**Shading > X-Ray Joints**].
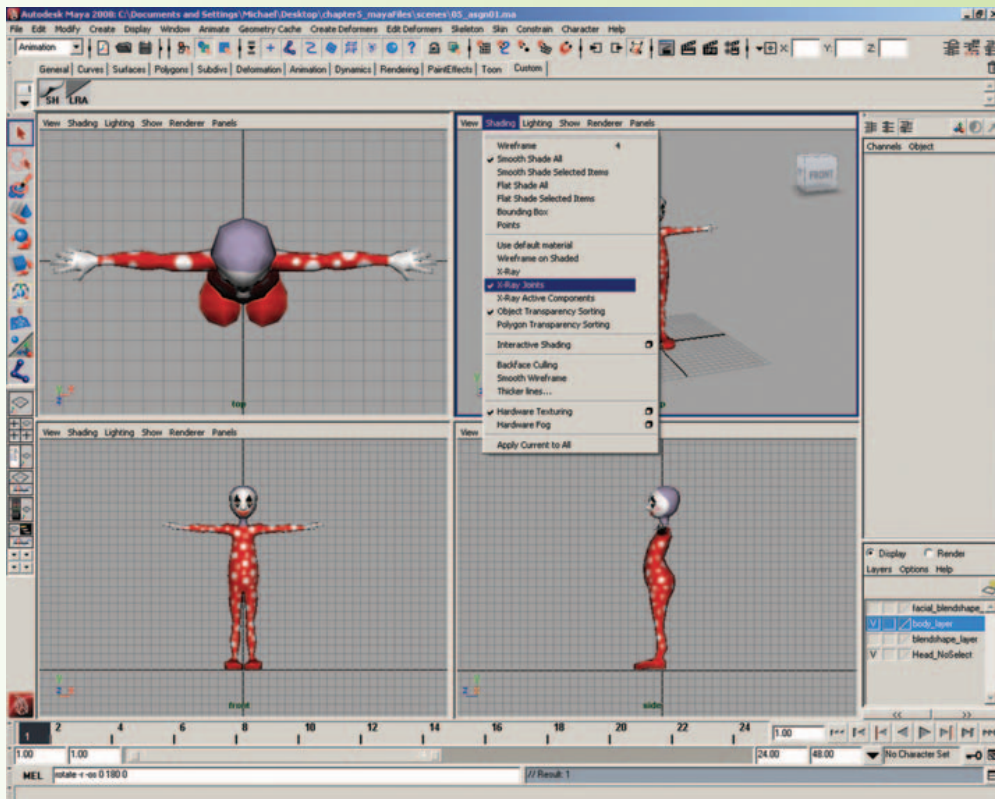
Setting all four view panels to X-Ray Joints mode.
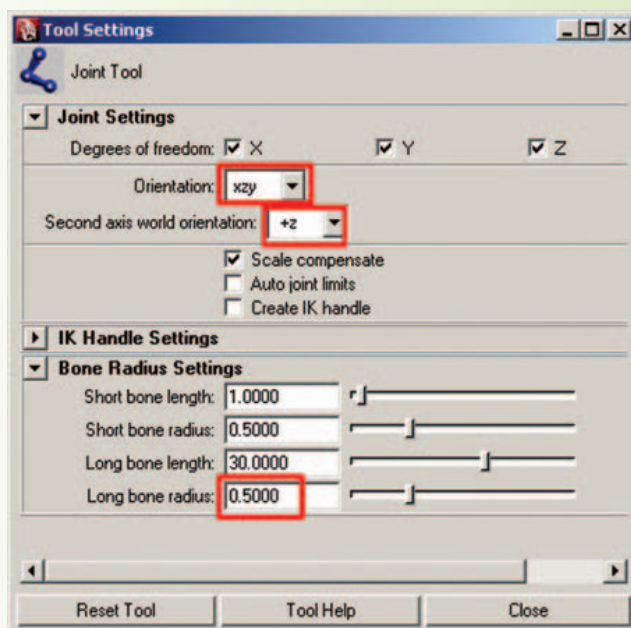
The Joint tool option settings.

4. Make sure that your geometry layer is set to **R** for reference. This ensures that you are unable to select the geometry by mistake when working.

5. Select the [**Skeleton > Joint Tool – option box**], or double click on the icon on the shelf. In the option window, click on RESET TOOL, then set the following:

    a. change the orientation to **XZY**.

    b. change the second axis world orientation to **+Z**.

    c. click close.

6. Select [**Skeleton > Joint Tool**] and click out a few joints in the orthographic view near your character. Go to [**Display > Animation > Joint Size**] and adjust the slider to adjust the size of the joint. Select the joints using the select tool – by pressing (**q**), and hit the delete key, as these joints were only created to set the joint display size.
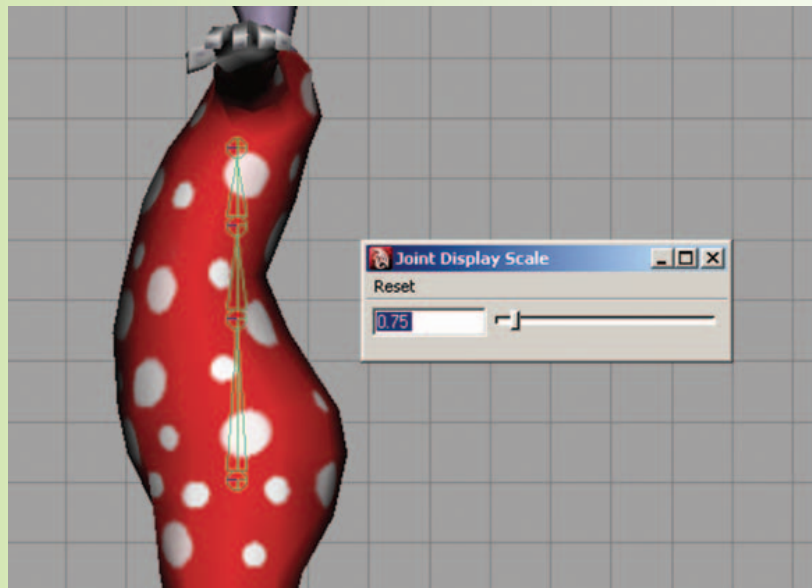

Adjusting the display size of the joints.

> **!** If the textures become distracting, press the **(5)** key to turn off hardware texturing.

7. Create the spine joint hierarchy by doing the following:

    a. In the FRONT orthographic view, **place 6 joints** for the spine as follows:

        Click the **first joint** in the waist area, hold down the **shift key** and click the **second joint** just above the first, and continue to the shoulder area. One joint is placed at the base of the rib cage, and the sixth joint is placed in the center of the shoulders. Hit **enter** to finish the chain. (It is important to keep the joints in the spine straight, even if your character has an exaggerated posture or curved back. Holding down the shift key as you click your joints ensures that they are drawn in a straight line.)

   b. Rename these joints *spine1*, *spine2*, *spine3*, *spine4*, *spine5*, and *spine6*.

> **!** You can rename the joints easily by selecting joint1 and opening [Modify > Search and Replace Names…] then enter the following: Search for: **joint** Replace with: **spine**.

c.   In the SIDE orthographic view, select the **spine1** joint and adjust the position in
the torso geometry if necessary.
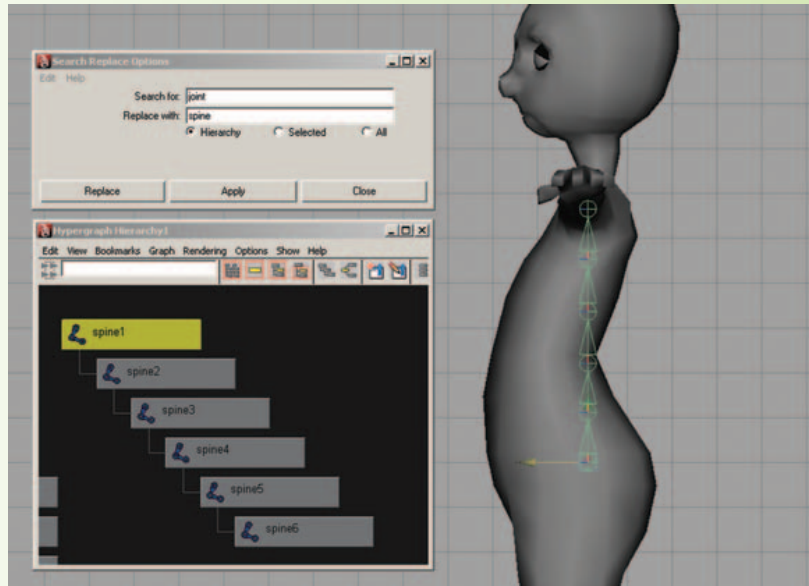
Positioning and renaming the *spine* joints.

d.   In the SIDE view, **place 1 joint** below the spine1 joint, rename this joint *pelvis*.
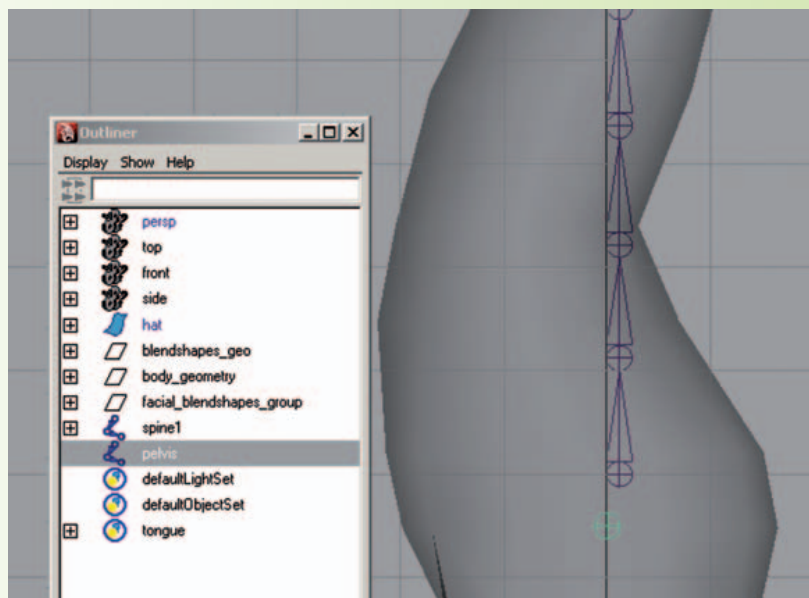
Placing the *pelvis* joint.

1.   Create the neck and head joint hierarchy by doing the following:

a.   Select [**Skeleton > Joint Tool**]

b. In the SIDE orthographic view **place 3 joints** for the neck and head as follows:

Click the **first joint** in the center of the neck, hold down the **shift key** and click the **second joint** at the base of the head. Keep the shift key held down and click the **third joint** at the top of the head. Hit **enter** to finish the chain.

c. Double-click on each joint in the outliner to rename them as follows: *neck, head,* and *headTip*.
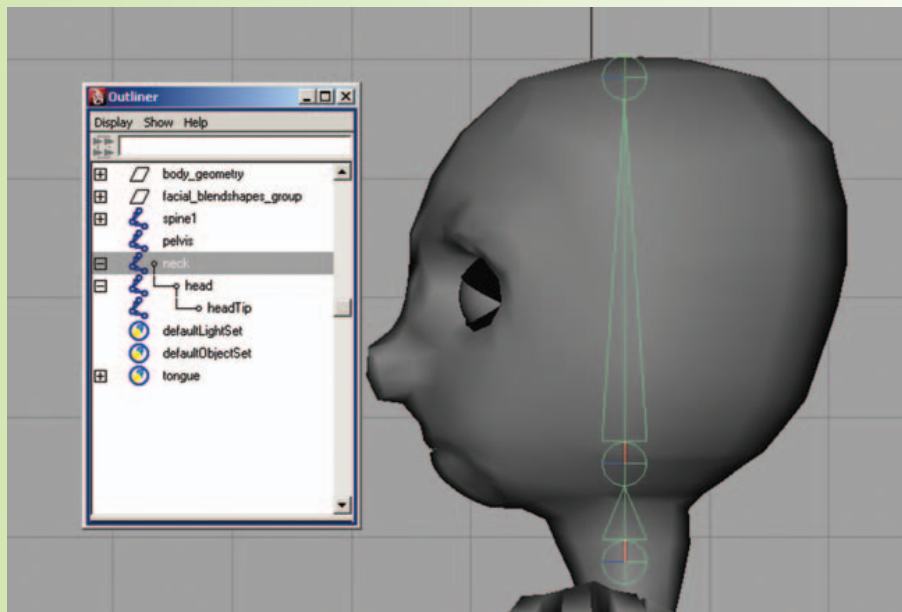
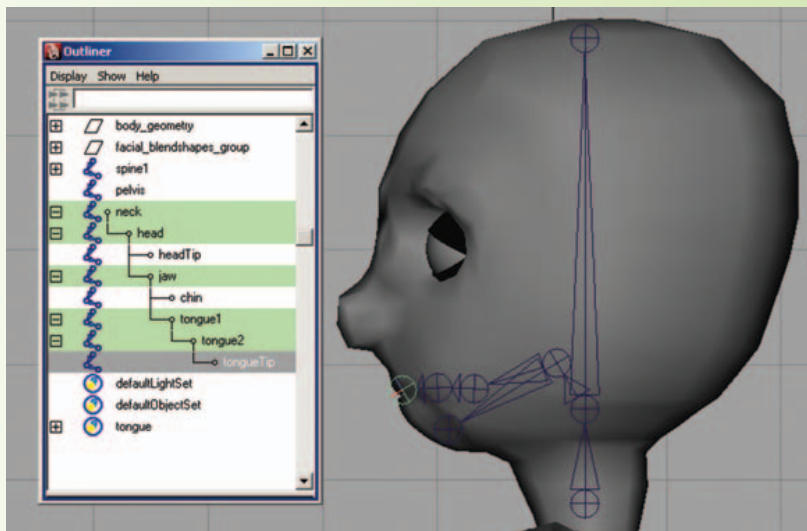**Placing and renaming the *neck* and *head* joints.**

> ! If your character has a mouth, you can control the mouth opening and closing with joints instead of blend shapes. Some prefer this control as it looks more natural, since our mouth opens from the rotation of our jaw.

2. Create the jaw joint hierarchy by doing the following (optional):

a. Select the joint tool by pressing **(y)** on the keyboard.

b. In the SIDE orthographic view, click FIRST on the *head* joint to begin a new chain that is branching from the *head* joint. Place **2 joints** for the jaw as follows:

Click the **first joint** at the base of the ear where the jaw hinges and the **second joint** in the chin. Hit **enter** to finish the chain.

c. Rename these joints *jaw* and *chin*.

3. Create tongue joint hierarchy by doing the following (optional):

a. Select the joint tool by pressing **(y)** on the keyboard.

b. In the SIDE orthographic view, click FIRST on the *jaw* joint to begin a new chain. Then **place 3 joints** for the tongue as follows:

Click the **first joint** at the back of the tongue, the **next** in the middle, and the **third** on the tip. Hit enter to finish the chain.
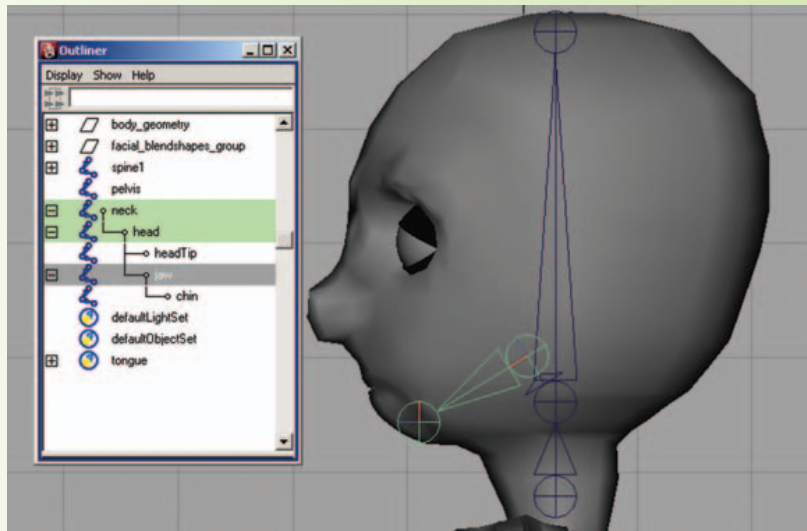
Placing and renaming the *jaw* joints.

   c.   Rename these joints *tongue1*, *tongue2*, and *tongueTip*.

Placing and renaming the *tongue* joints.

4.   Save your scene file. Name your scene *05_asgn01.ma*.

! The number of joints is suggested and what I would consider the minimum amount needed. You can always add more joints for more flexibility or necessity. For example, if your character has a big nose, you may want to add a two or three joint chain stemming from the head joint so that you can control the nose movement. A *blend shape* can also be used for the nose movement. In summary, it is better to have a few extra joints than not enough at all.

Assignment 5.2: Creating an Arm and Hand Skeleton

1. Continue working on scene *05_asgn01.ma*.

2. Create the arm joint hierarchy by doing the following:

    a. Select [**Skeleton > Joint Tool**]. Keep the *orientation* to **XZY** and the *second axis world orientation* to **+Z**.

    b. In the FRONT orthographic view **place 5 joints** for the arm as follows:
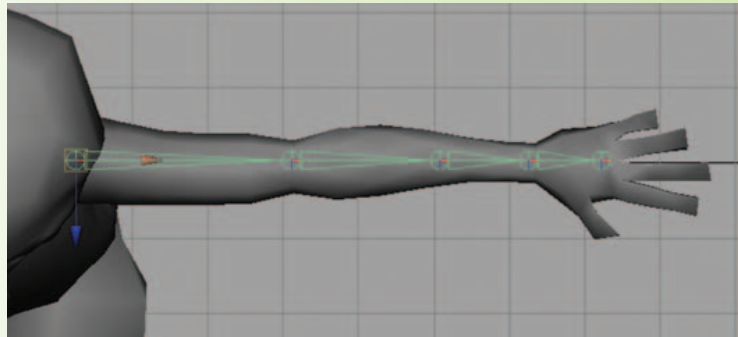
    Click the **first joint** in the shoulder.

> **!** The shoulder is probably the toughest joint to position properly. Placing it too far into the arm geometry makes your arm bend bizarrely at the bicep instead of the shoulder. Placing it too far into your body geometry concaves your torso and breaks the shoulder. After we place all of our joints, we will test the position to see how things look when they bend. Fine tuning the position of the shoulder will occur at that time.

    c. While holding down the **shift key** click the **second joint** in the elbow, the **third joint** in the forearm, the **fourth joint** in the wrist, and the **fifth joint** in the palm of the hand. Hit enter to finish the chain. Holding the shift key ensures that the arm is drawn in a straight line.

    d. Rename these joints *shoulder, elbow, forearm, wrist, and palm*.
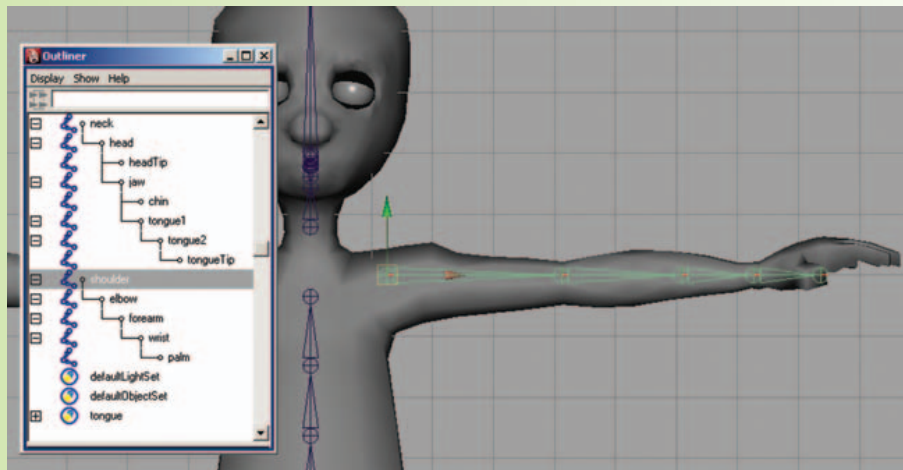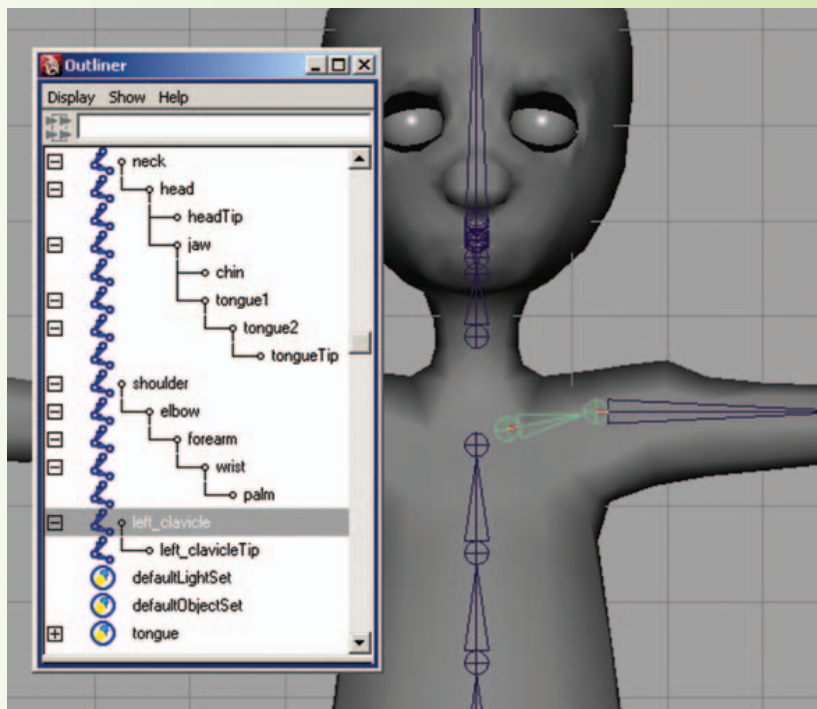

Placing and renaming the *arm* joints.

    e. In the TOP orthographic view, select the **shoulder joint** and adjust the position in the arm geometry if necessary. Remember, it is not necessary to reorient a chain if it is moved in its entirety. (Our arms do not actually have a forearm joint. What we do have is a radius and an ulna that allows rotation of the forearm. The forearm joint will act as the radius and ulna, which will allow for rotation of the forearm without rotation of the elbow.)
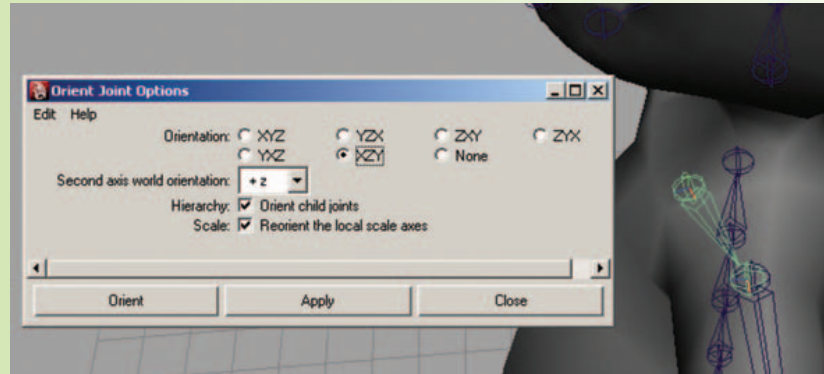
Repositioning the *arm* joints.

f.   In the FRONT orthographic view **place 2 joints** for the clavicle.

Click the **first** near the spine, at the base of the clavicle. While holding down the **(v) key**, click the **second** joint in the existing shoulder joint. The **(v) key** turns the point snap, which will snap the new joint into the same position as the existing shoulder joint. Hit enter to finish the chain.

g.   Rename these joints *left_clavicle* and *left_clavicleTip*.

Placing and renaming the *clavicle* joints.

h.   In the PERSPECTIVE view, check for proper alignment. Select the *left_clavicle* joint, and with the move pivot tool, translate the joint to the front of the geometry. (To get to the move pivot tool, press **(w)** then hit the insert key.)

i. Since we moved the joint we must reorient. With the *clavicle* joint selected, go to [**Skeleton > Orient Joint – option box**]. Choose orientation: **XZY** and second world orientation: **+Z** then click **ORIENT**.

Repositioning and reorienting the *clavicle* joints.

! After creating the hands, we will mirror the left arm to create the right arm.

3. Create the hand joint hierarchy by doing the following:

   a. Select [**Skeleton > Joint Tool**]

! While it is not necessary to have four fingers and a thumb for your character, I recommend a minimum of a thumb and middle finger, or mitt. Since our hands are such an expressive part of our body, it is important to be able to gesture with them.

   b. In the TOP orthographic view, click FIRST on the *palm* **joint** to begin a new chain for a finger that is branching from the *palm* joint. **Place 4 joints** for the middle finger, placing 1 at each knuckle (observe your own hand for clues about joint placement) and one on the tip of the finger (the last joint is placed to allow the prior joint to bend, the last joint never rotates). Hit **enter** to finish the chain.

   c. Rename the finger joints as follows: *middle1*, *middle2*, *middle3*, *middleTip* (You can rename the joints easily by selecting joint1 and opening [**Modify > Search and Replace Names…**] then enter the following: Search for: **joint** Replace with: **middle**, and then relabel *middle4* as *middleTip*).

   d. Repeat this process for the index and ring finger, if your character has them. Press the **(y) key** to choose our last tool – the joint tool. Click FIRST on the *palm* joint, and then **place 4 joints** for the index finger. Hit **enter** to finish the chain.

   Rename the finger joints as follows: *index1*, *index2*, *index3*, *indexTip* (You can rename the joints easily by selecting joint1 and opening [**Modify > Search and Replace Names…**] then enter the following: Search for: **joint** Replace with: **index**, and then relabel *index4* as *indexTip*).

e.   Press the **(y)** key to choose our last tool, click FIRST on the *palm* joint, and then **place 4 joints** for the ring finger. Hit **enter** to finish the chain. Rename the finger joints as follows: *ring1*, *ring2*, *ring3*, *ringTip* (You can rename the joints easily by selecting joint1 and opening [**Modify** > **Search and Replace Names…**] then enter the following: Search for: **joint** Replace with: **ring**, and then relabel *ring4* as *indexTip*).
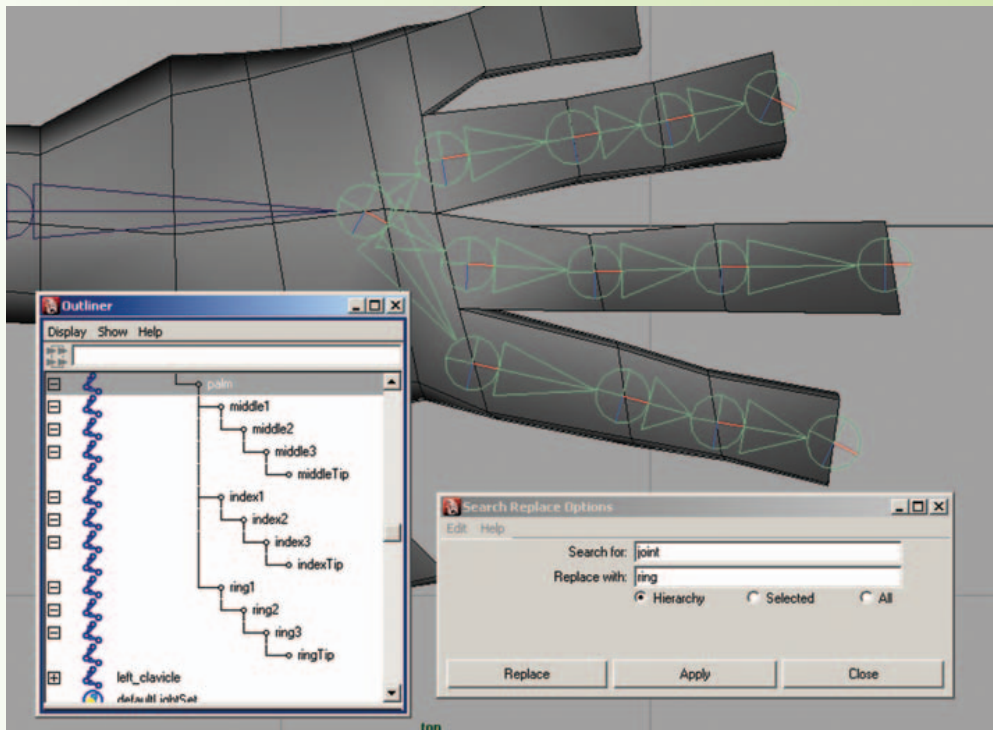
**Placing and renaming the *middle*, *index*, and *ring* finger joints.**

! The pinky and thumb joints will be a little different than the index and ring fingers in that they will start down near the base of the hand at the wrist. You are not stemming the pinky finger or thumb from the palm because you want them to work independently of the three middle fingers, allowing you to pose the hand into a cupped position.

f.   Press the **(y)** key to choose our last tool, click FIRST on the *wrist* joint, and then **place 5 joints** for the pinky finger as follows: place 1 joint for the pinky side of the palm as well as 4 joints for the pinky finger. Hit **enter** to finish the chain.

Rename the finger joints as follows: *pinkyPalm*, *pinky1*, *pinky2*, *pinky3*, *pinkyTip*.

Press the **(y)** key to choose our last tool, click FIRST on the *wrist* joint, and then **place 4 joints** for the thumb as follows: place 1 joint for the thumb side of the palm as well as 3 joints for the thumb. Hit **enter** to finish the chain. Rename the finger joints as follows: *thumbPalm*, *thumb1*, *thumb2*, *thumbTip*.
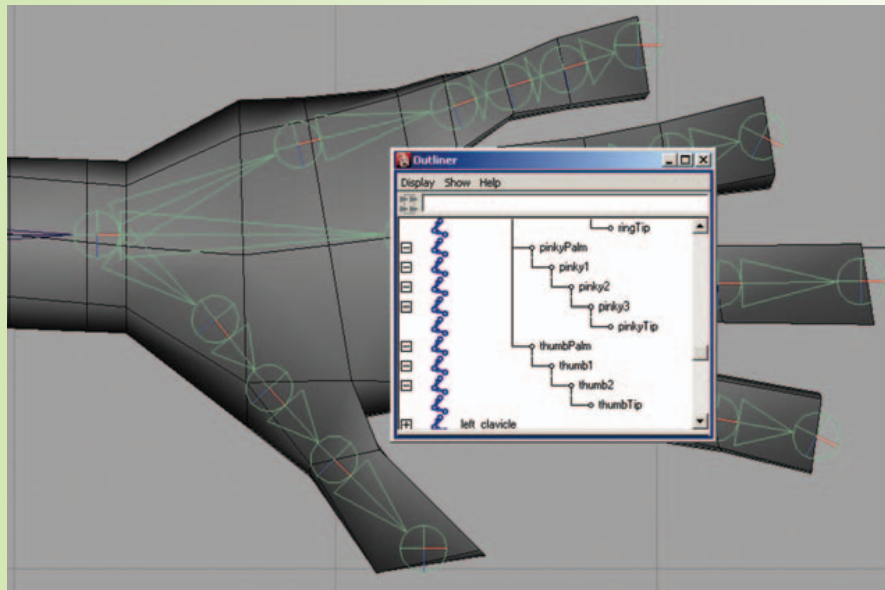
**Placing and renaming the *thumb* and *pinky* finger joints.**

g. In the PERSPECTIVE view, move or rotate the finger joints so that they line up on the top edge of the geometry. By doing this, your character's geometry will bend and deform more realistically. The first knuckle of each finger should be set back slightly in the hand. Look at your own hand for reference and notice where the knuckles are.

Before positioning the joints

After positioning the joints
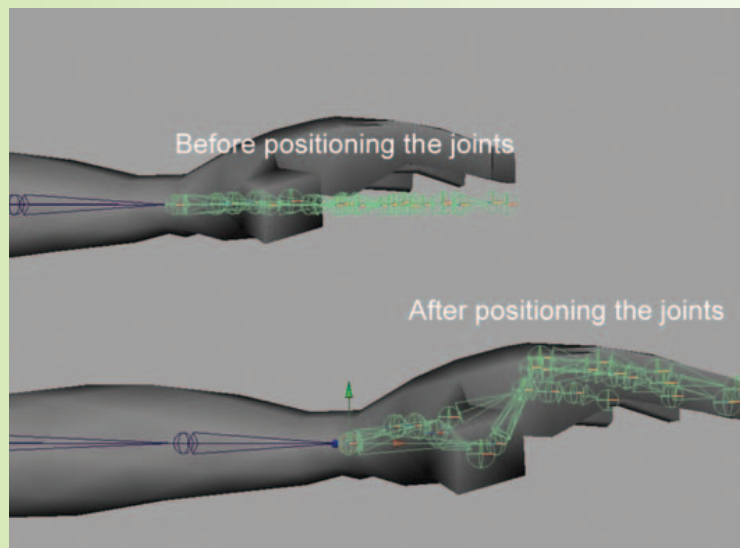
**Repositioning the *finger* joints in the perspective window.**

! DO NOT MOVE THE PALM JOINT. It is important that the palm stay in line with the wrist so that the hand works predictably with the control rig.

h. If you rotated any of the joints, you should freeze transformations on the rotations. Select the *wrist* joint and go to [**Modify > Freeze Transformations**]. Don't forget to open the option box and reset the options to default settings before applying.

i. If you moved any joints, make sure to reorient the joints in the hand once they have all been moved into place. Select the *wrist* joint and go to [Skeleton > Orient Joint – option box]. Choose orientation: **XZY** and second world orientation: **+Z** then click **ORIENT**.
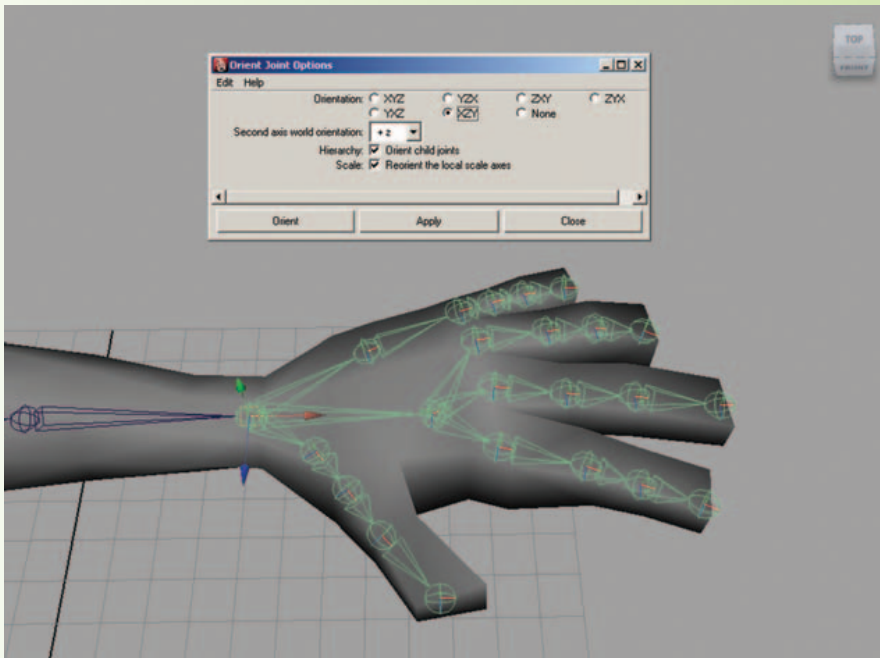
Reorienting the joints in the hand.

j. Rename your arm chain to include left_ prefix by selecting the *shoulder* joint, then go to [**Modify > Prefix Hierarchy Names…**]. Enter **left_** in the text field and click **OK**.
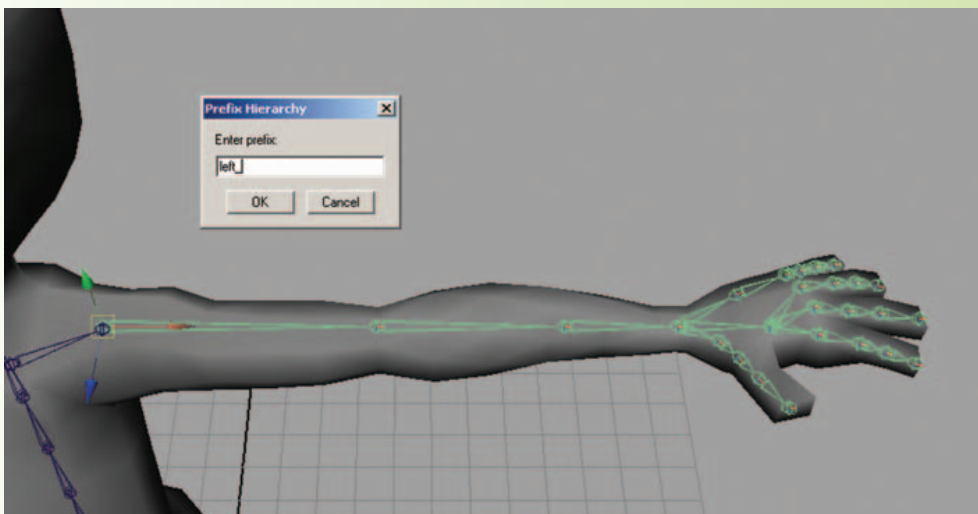

Adding the *left* prefix to the arm chain.

k. Mirror the left arm to create the right arm by selecting the *left_shoulder joint*, then go to [**Skeleton > Mirror Joint – option box**] and enter the following:

Mirror Across: choose **YZ** axis (Mirroring across the YZ axis will mirror from left to right – on the X axis. This can be slightly confusing at first. An easier way to think about the direction is to establish a line on the missing axis (X in this case) and that is the direction of your mirrored skeleton. Another way is to imagine a flat plane created by the stated axis YZ – up and down PLUS front to back (hey … imagine a mirror … like a full length one that you have on your wall). THE mirrored skeleton is the reflection on that axis (or in that mirror).)
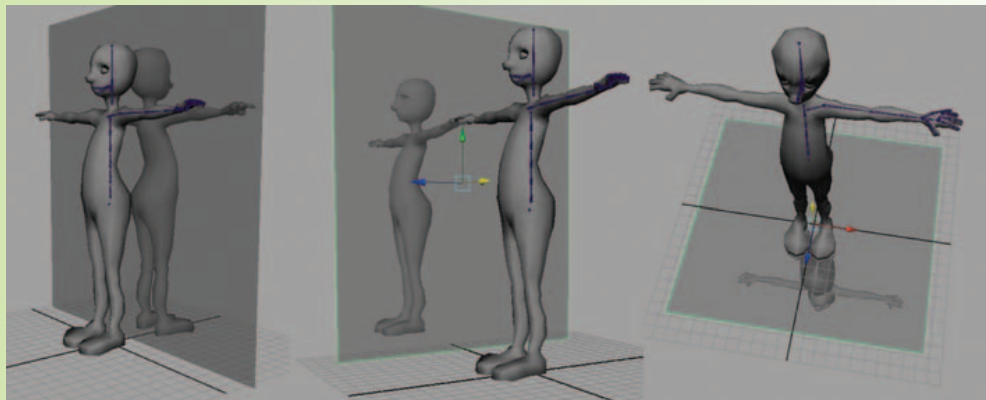
Establishing the mirror direction as a *reflection*. Mirroring on the XY (left), mirroring on the YZ (middle), and mirroring on the XZ (right).

Mirror Function: choose **behavior** (Mirroring your joints with "behavior" allows for the animator to choose both elbows and rotate them simultaneously in the same direction. This usually means that the X axis is rotated 180 degrees, pointing away from the child joint. Mirroring your joints with **orientation** keeps the X axis pointing toward the child joint. Either will give you the results needed, but **behavior** seems to be most popular with animators because it speeds up the posing process when animating in FK.)
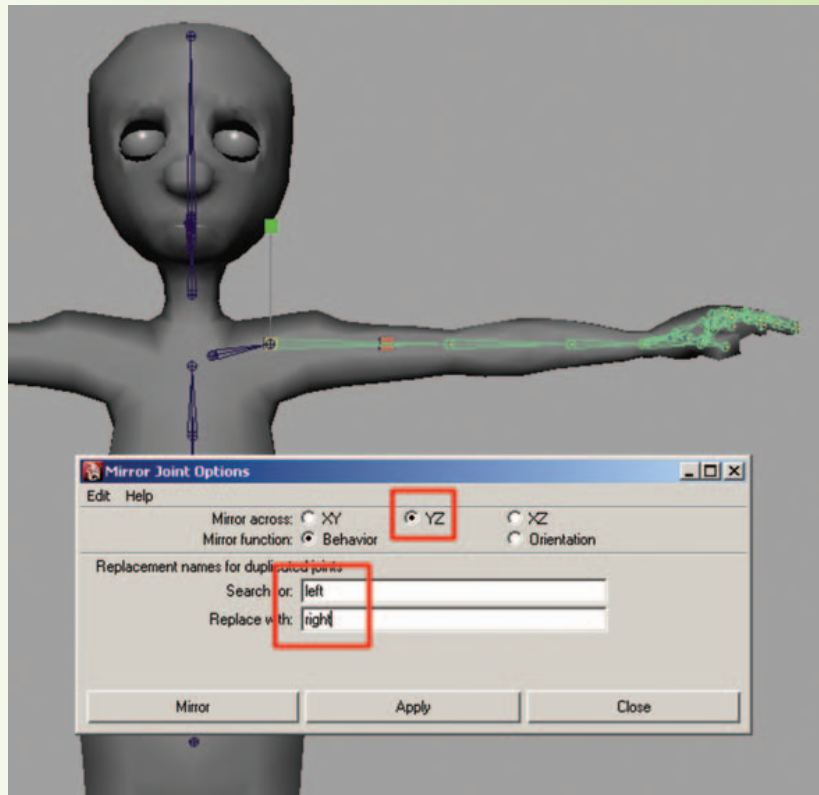
Replacement names for duplicated joints:

Search For: enter **left**

Replace With: enter **right**

Then click **mirror** to execute the command.

l. Mirror the left clavicle to create the right clavicle by selecting the *left_clavicle joint*, then go to [**Skeleton > Mirror Joint**] or hit the **(g) key** to repeat the last command.

4. Save your scene file. Name your scene *05_asgn02.ma*.

The mirror joint options.

Assignment 5.3: Creating a Leg Skeleton

1. Continue working on scene *05_asgn02.ma*.

2. Create the leg joint hierarchy by doing the following:

   a. Select [**Skeleton > Joint Tool**]. Keep the *orientation* to **XZY** and the *second axis world orientation* to **+Z**.

   b. In the SIDE orthographic view, **place 5 joints** for the leg as follows:

   Click the **first joint** in the hip.

   c. Click the **second joint** in the knee, the **third joint** in the ankle, the **fourth joint** in the ball of the foot, and while holding down the **shift key**, click the **fifth joint** at the tip of the toe. Hit **enter** to finish the chain. Holding the shift key ensures that the toe is drawn in a straight line from the ball. (If your character's leg geometry is bent, be sure to draw the knee in a bent position. However, be careful not to overdo the bend as this will cause hyperextension of the knee when the leg is straightened. For this reason, if your character's leg geometry is straight, make sure to draw the knee and ankle straight down from the hip. Holding the shift key ensures that the joints are drawn straight.)

   d. Rename these joints *hip, knee, ankle, ball, and toe*.

Placing and renaming the *leg* joints.
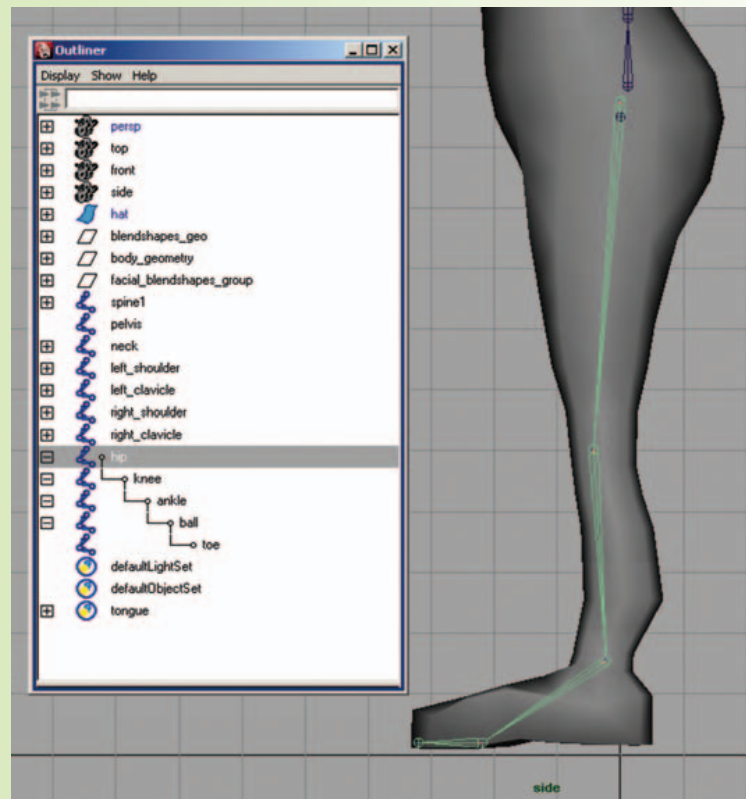
e.   In the FRONT orthographic view, select the ***hip* joint** and move the joint chain along the **X axis (the red arrow)** into the left leg of your character's geometry. Remember, it is not necessary to reorient a joint chain if it is moved in its entirety.

Repositioning the *leg* joints in the FRONT orthographic view panel.
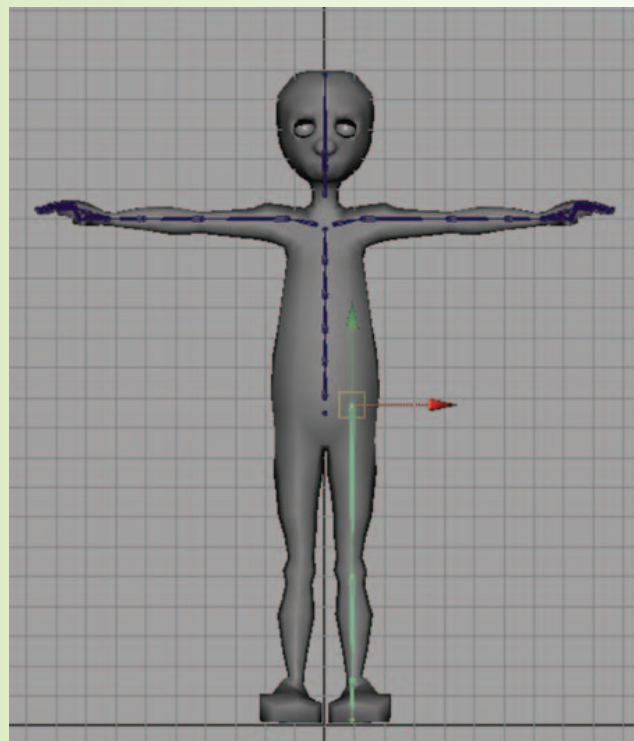
! DO NOT move the *knee* or *ankle* out of alignment in the front view. The entire leg must be straight in the front view for predictable IK movement. If necessary, you can ROTATE the entire chain from the *hip* joint to align the leg. Remember to go to [Modify > Freeze Transformations] if rotations are used to position the joint chain.

    f.   Rename your leg chain to include left_ prefix by selecting the **hip** joint, then go to [**Modify > Prefix Hierarchy Names...**]. Enter **left_** in the text field and click **OK**.

    g.   Mirror the left hip to create the right hip by selecting the **left_hip** joint, then go to [**Skeleton > Mirror Joint**].
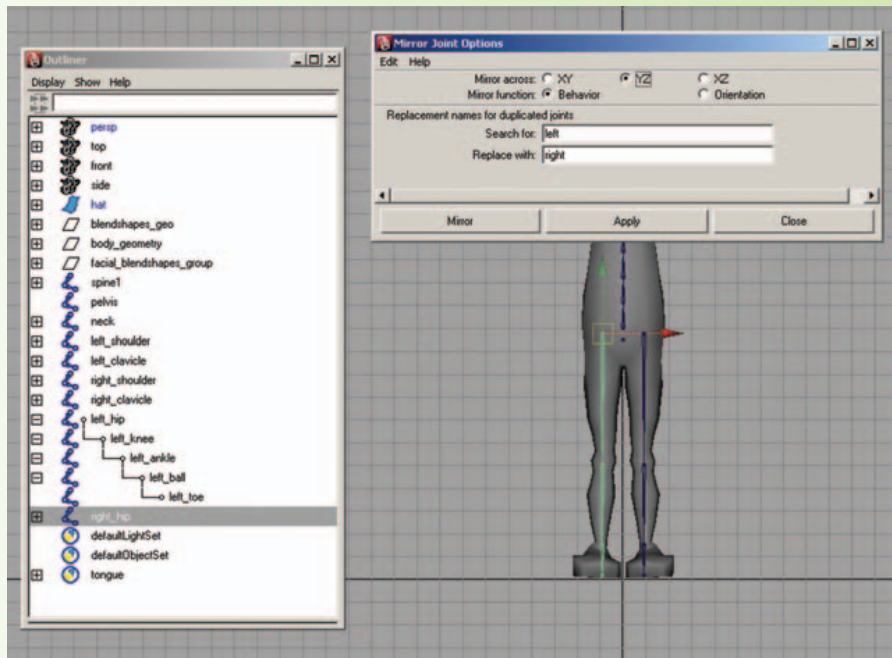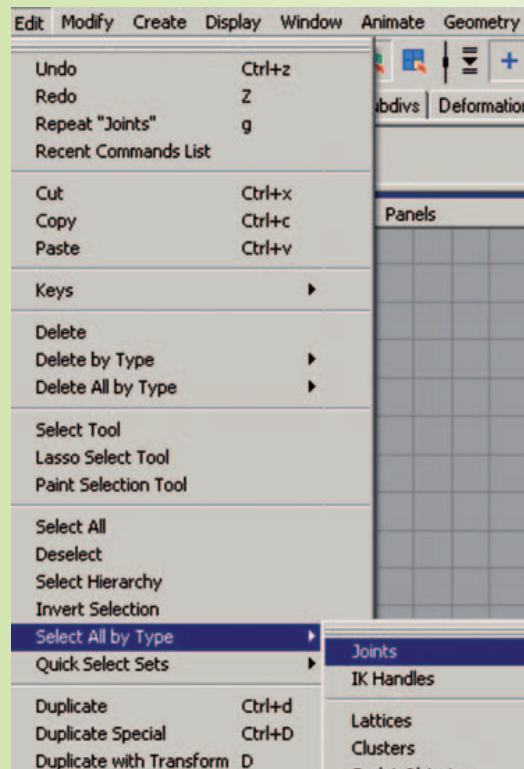

Mirroring the left leg to create the right leg.

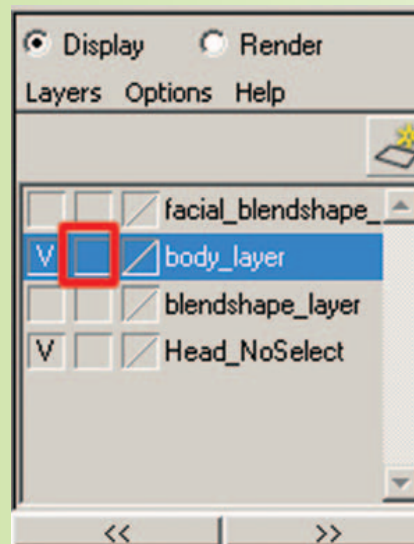3.   Save your scene file. Name your scene *05_asgn03.ma*.

Assignment 5.4: Test the Joint Placement

1.   Continue working on scene *05_asgn03.ma*.

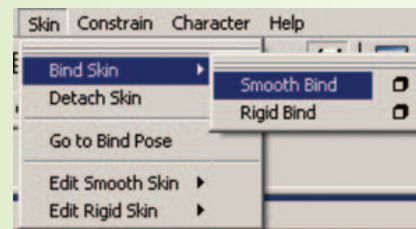2.   Select all joints by going to [**Edit > Select All By Type > Joints**].

Selecting all of the joints.

3. Make sure that your geometry layer is set to *normal* by clicking on the **R** until the box is empty so that you are able to add the geometry to the selection.

4. Hold down the **shift key** and click on the character geometry piece(s).

5. Create a test skin bind by going to [**Skin > Bind Skin > Smooth Bind**].

6. Return your geometry layer back to *reference* by setting the layer to **R** so that you are unable to select the geometry by mistake when testing the joints.

7. Select a **shoulder joint** and rotate it so that the arm is down. Check the movement on the elbows, the knees, and the hips. These areas are the most problematic. What we are looking for is proper joint placement and verification that
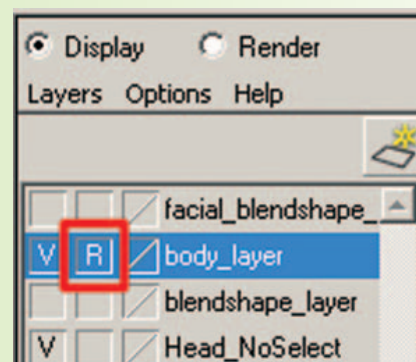

Changing the geometry layer to *normal*.

Creating a skin deformer.

Changing the geometry layer back to *reference*.
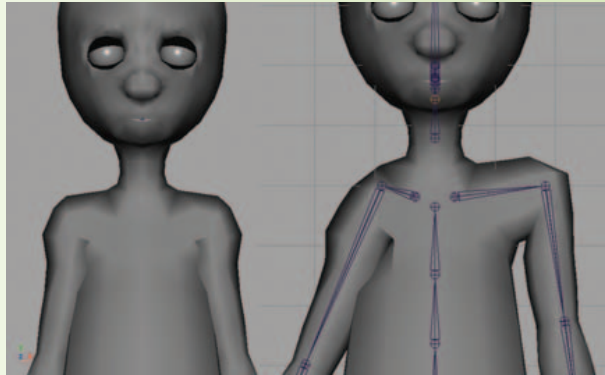
the bending of the shoulder, elbow, knee, and hips provide natural deformation that holds the shape. Refer to the images below to verify what is acceptable, and what is not.

Good deformations on the character's shoulders on the left, and bad deformations caused by improper joint positions on the character's shoulders on the right. The right image shows two common problems. The left shoulder (right image) has a joint that is placed too far into the bicep. The right shoulder (right image) has a joint that is placed too far into the body.
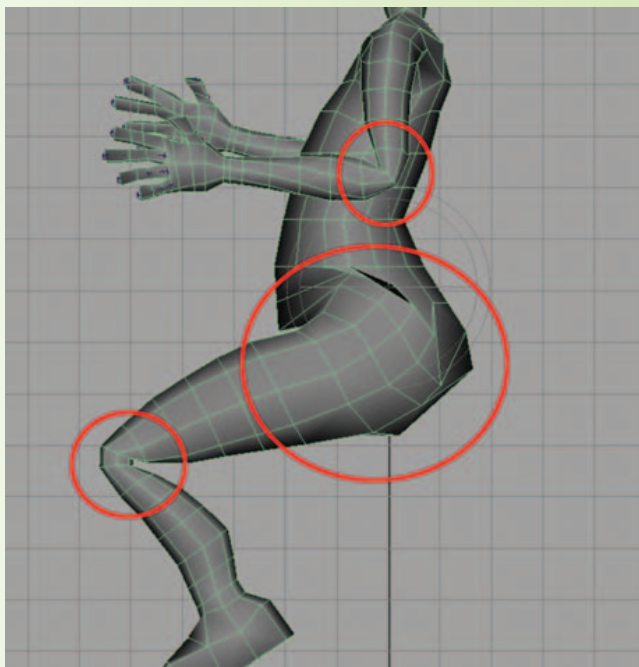

The area around the waist may look like it is cracking and indenting. This is not a joint placement issue, but rather, the skin deformer needs to be smoothed in this area (covered in Chapter 8). The elbows and the knees are pinching because there are not enough divisions in the geometry to make a smooth bend.

Think about the difference between a regular straw and a flexi-straw. A regular straw pinches when it bent (left). A flexi-straw can bend more smoothly because of the added divisions allowing it to bend (right).

! If you move a joint and the geometry is pulled bizarrely or pushed into the body, note that this is NOT a joint placement problem. Any indentions and pulling of geometry can be fixed during the *Paint Skin Weights* process covered in Chapter 8.

8. **DO NOT SAVE THE FILE.**

9. If no changes are necessary, reopen the file *05_asgn03.ma, save the file as 05_asgn04.ma* and continue with Assignment 5.5.

10. If changes are necessary, reopen the file *05_asgn03.ma*, take your move pivot tool – press the **(w)** then press the **insert key** and move the joints ONLY on the **X axis (the red line)** to place them into a better position. Adjust the left side only.
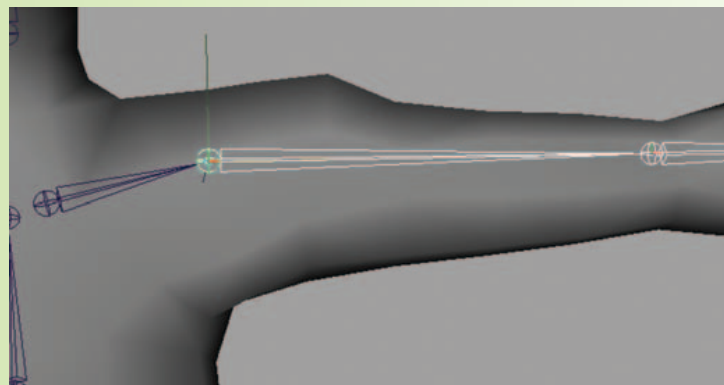
Repositioning joints in the shoulder.

11. With the joint chain selected, reorient by going to [**Skeleton > Orient Joint –
     option box**]. Choose orientation: **XZY** and second world orientation: **+Z** then
     click **ORIENT**.

12. If there is a problem with the left arm or leg, then the right arm and leg will also
     need to be fixed. Simply delete the right chain in question (select in the outliner and
     hit the delete key) and select the left joint chain and go to [**Skeleton > Mirror Joint**]
     to re-mirror the right side.

13. If there is a problem with the geometry due to inadequate divisions, you must update
     the character model. Since your file is still referenced, you must open the referenced
     model file and make changes there by doing the following:

     a. Delete the non-deformer history first by going to [**Edit > Delete by
         Type > Non-Deformer History**]. (This ensures that the blend shape deformer is
         not removed.)

     b. Then add extra geometry in the troubled areas using the [**Edit NURBS > Insert
         Isoparms**] tool for NURBS surfaces (refer to Chapter 2 for more details on
         how to insert isoparms). Use the [**Edit Mesh > Insert Edge Loop Tool**] for
         Polygons.

     c. Since the geometry has a Blend Shape deformer applied, be sure to [**Blend
         Shape > Bake Topology to Targets**]. (Refer to Chapter 3 for more details on
         how to add topology to your blend shapes.)

14. Save your scene file *05_asgn04.ma*.

15. Follow the steps above until the proper movement is achieved.

> **!** There is a new tool in Maya 2008 called the *Move Skinned Joints Tool*. It provides the
> ability to reposition joints quickly while the character is still bound to the skin. This tool
> is helpful to promptly check to see if the new position will work for the skin deformer.
> Don't forget to reorient the joint chain while the tool is still in use, and to [Skin > Detach
> Skin] the geometry when completed, if you use this tool to reposition the problem joints.

Assignment 5.5: Verifying the Joint Local Rotation Axis

Your joint local rotational axes should already be correct for your skeleton, assuming
that you placed your joints correctly (with orientation: XZY and second world orientation:
+Z), froze transformations when necessary (when you rotated or scaled joints into
position), and reoriented them if they were moved after the original placement. The
thumb joints are the only joints that will definitely need tweaking for their position. The
wrist joints might need a slight adjustment, also.

It is a great idea to verify that all of the joint local rotational positions are correct before
beginning to build your controls in Chapter 6.

1. Continue working on scene *05_asgn04.ma*.

2. Let's first evaluate the axes and determine if any need to be fixed.

    a. Select all joints by going to [**Edit > Select All By Type > Joints**].

    b. Then go to [**Display > Transform Display > Local Rotation Axes**].

c. The torso, neck, head, left arm, hand, and leg should have the X axis pointing toward the child and the Z axis coming forward.
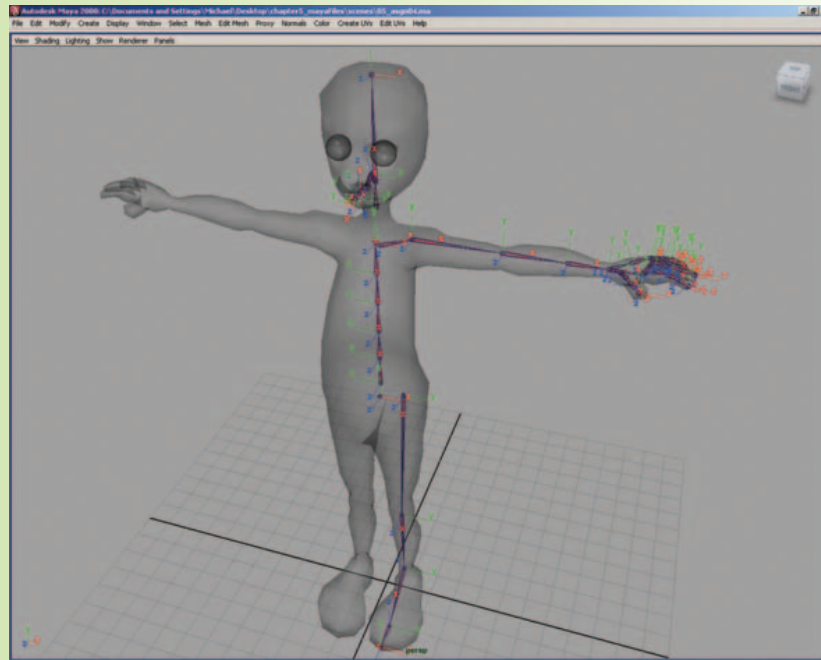

The proper Local Rotation Axis for the joints.

d. The right arm, hand, and leg should be mirrored on behavior, and therefore the X axis should be pointing away from the child and the Z axis pointing backward.
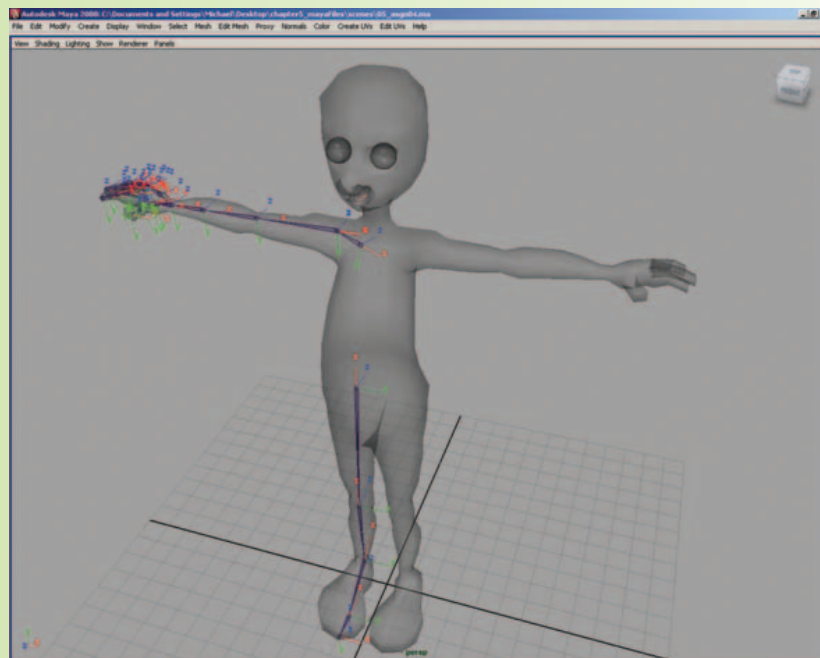
The proper Local Rotation Axis for the right arm and leg.

> **!** Remember, the last joint of any chain will not rotate and therefore the local rotation axis position does not matter for that joint.

3.   If there is a problem with the orientation on the torso, neck, head, left arm, hand, or leg, simply select the top of the joint chain by opening the outliner [**Window > Outliner**] and choose the top joint, then reorient by going to [**Skeleton > Orient Joint – option box**]. Choose orientation: **XZY** and second world orientation: **+Z** then click **ORIENT**.

4.   If there is a problem with the left arm, hand, or leg, then the right arm, hand, or leg will also need to be fixed. Simply delete the right chain in question (select in the outliner and hit the delete key) and select the left joint chain and go to [**Skeleton > Mirror Joint**] to re-mirror the right side.

5.   Turn off the Local Rotation Axes Display as follows:

     a.   Select all joints by going to [**Edit > Select All By Type > Joints**].

     b.   Then go to [**Display > Transform Display > Local Rotation Axes**].

6.   The wrist joints and the thumb joints will need to be adjusted manually as follows:

     a.   Select the *left_wrist* joint, then shift select the *right_wrist* joint.

     b.   Press **(F8)** on the keyboard to change to component mode or click on the **component mode button**. In the selection mask tool bar, **LMB** click on the points button to turn it off and **RMB** click and hold the "**?**" button and select **Local Rotation Axes** from the marking menu that appears.
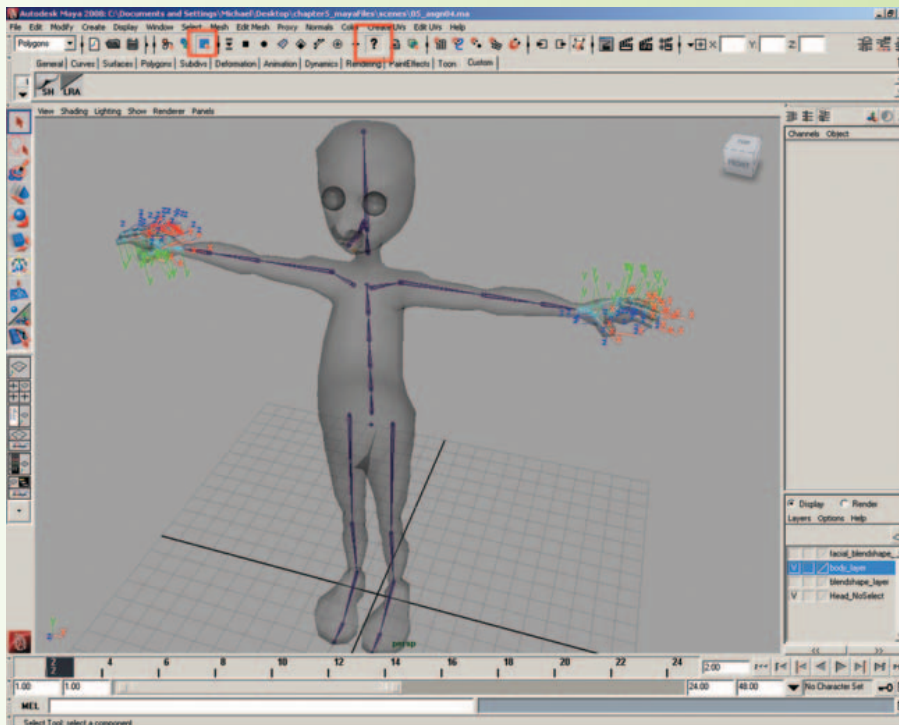
Displaying the Local Rotation Axis in component mode.

c. Starting with the left thumb, use the selection tool – **press (q)** – to click on the *thumb_palm* **axis**. Holding down the shift key, click the *thumb1* **axis**, and the *thumb2* **axis**. Rotate – **press (e)** – the *thumb_palm*, *thumb1*, **and** *thumb2* axes so that the Y axis is intersecting the joint in the direction the bend will occur.

right thumb   left thumb
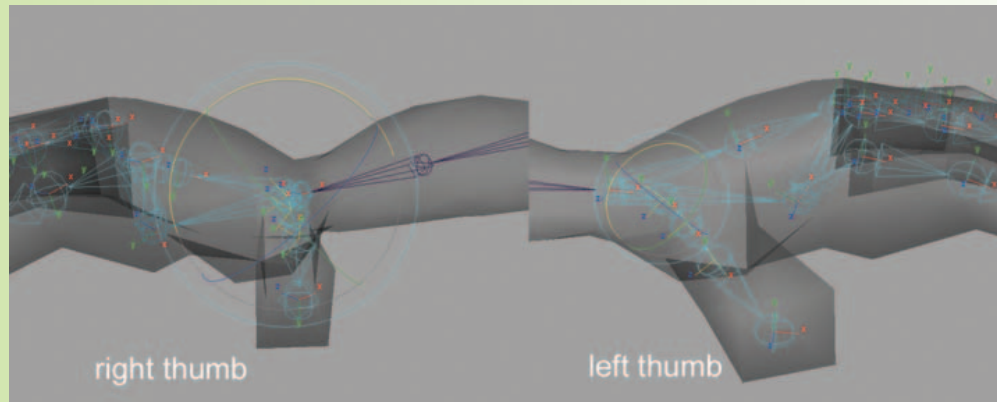
**Rotating the thumb Local Rotation Axis into position.**

d. Repeat this for the right thumb. On the right side, the Y axis comes out the underside of the thumb.

! To visualize this, hold your hand in the same position that your character's hand is modeled. Pick up a pen or pencil and IMAGINE – do not really do this – IMAGINE that pen or pencil being jabbed into your thumb knuckle and coming out of the other side. That pen would be the Y axis.

Visualizing the direction of the Y axis by using a pen.

7.   In the TOP orthographic view, verify that the wrist local rotational axis is aligned straight with the graph. To do this, click on the wrist axis and select the rotate tool by pressing **(e)** on the keyboard. The inside of the tool should appear as a **+** and be even with the graph. If not, carefully rotate the **Y axis (the green part of the rotate tool)** until the **+** aligns with the graph.
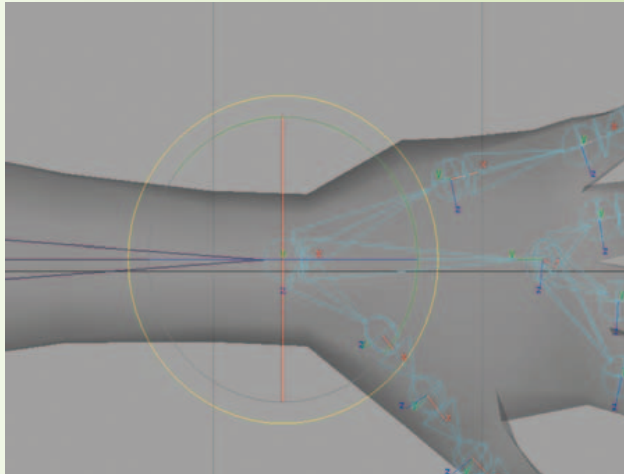
Verifying that the wrist Local Rotation Axis is straight.

8.   Save your scene file *05_asgn05.ma*.

> **!**   At any time you can go back and fine tune your joint orientations if necessary.

Assignment 5.6: Adding Additional Joint Chains for Clothing, Tails, Antennae, or Other Areas

With the techniques you have learned in this chapter, you can add additional joint chains for anything else on your character that needs control: neckties, ponytails, skirts, tails, antennae, or ears, etc. Just remember, any joint chains that are vertical and have FK control need the Y axis pointing toward the child joint. Any joint chains that are horizontal (front to back) and have FK control need the Z axis pointing toward the child joint (like a tail). Any joint chains that are horizontal (side to side) and have FK control need the X axis pointing toward the child joint. Any joint chains controlled by IK need to have the X axis pointing toward the child joint. If the control is created using Set Driven Key (like the fingers), it really doesn't matter which axis points to the child, as long as the axes for the joints in the chain are consistently the same.