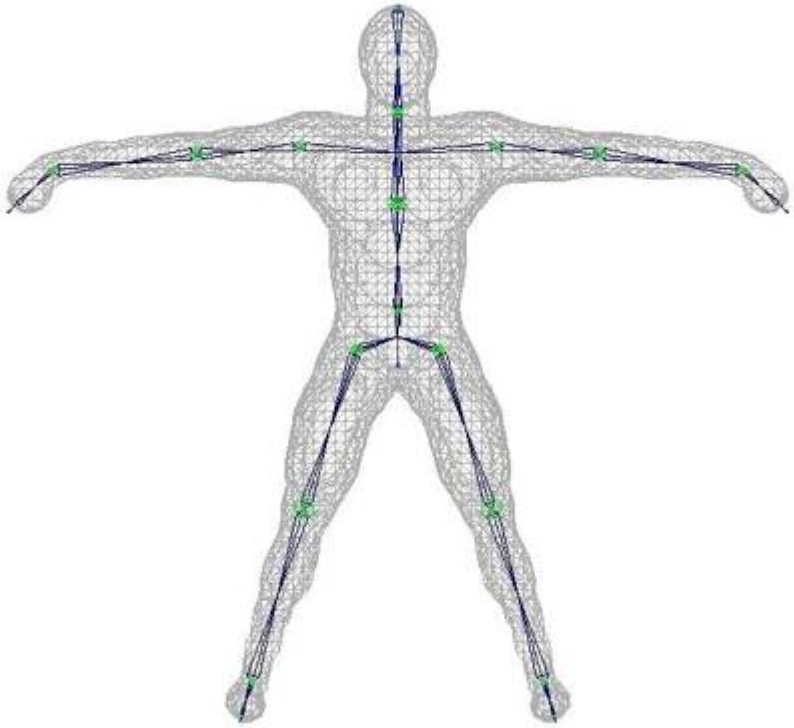
Advanced Bones With trueSpace 4.x

By Frank A. Rivera



trueSpace4's Bones features (skeletons and deformable skin) allow you to create and animate characters like never before possible. By now you have heard of bones and what they do. We know that they can be used to bring inanimate objects to life, unfortunately at the time of this writing a lot of trueSpace users find them a little intimidating. Believe it or not, trueSpace bones are easier to use then you might think.

In this chapter we will be looking at the mechanics involved in creating a skeleton for your bipedal humanoid characters. We will cover:

- Building a skeleton
- The Build Skeleton panels
- Creating a bone structure for bipedal humanoids
- Editing joints
- Attaching a skeleton to an object
- Editing tendons
- Editing muscles
- Adding and removing vertices from muscle groups

Bones and Humanoid Characters
In the Animation pre-cursor tutorial I skimmed over the Bones panels because all the functionality built into the Bones features wasn't needed for animating simple objects with bones. Here we will be

creating more complex skeletal structures therefore a review of the panels and tools involved is in order. As soon as we get the panels out of the way we will look at the practical applications of trueSpace bones.

To animate a character with bones, you first must link several bones together with joints. This creates a hierarchy called a skeleton. Bones (a skeletal deformation tool) perform the same basic tasks as other deformation tools in trueSpace, they deform a mesh's vertices, except in a controlled manner so the vertices move and flex like skin. Joints are just a method of linking two objects together (in this case bones) with the ability to adjust the amount of rotational freedom of the link itself. Like everything else in life, when using bones you have to have a good structure to build upon, so let's look at what's involved in building a bones structure.

Building a Skeletal Structure
There are three ways to build a skeleton in trueSpace4. You can:

1. Extract a skeleton from an existing IK object.
2. Manually create each bone and create each joint to construct the skeleton.
3. Build the skeleton by clicking your mouse where the joints should appear.

The Extract Skeleton from IK Object tool allows you to create a skeleton from an existing object with an IK structure by replacing the IK linked polyhedra with bones. An extracted skeleton retains the animation information of the original object. The original IK object remains unchanged, but the new skeleton can then be applied to another polyhedron by selecting the Attach Skin to Skeleton tool. When you load any object with an IK structure, trueSpace converts the IK structure to a bones structure for you automatically. There is something interesting about this tool. Let's try a short experiment:

Step 1. Load up the CaliBot.scn file. (Click here to get it).
Step 2. Click the Extract Skeleton from IK Object tool.
Step 3. Select the Caligari robot, and drag him to your left.

This should reveal a second bone structure[mf]an identical copy of the robot's skeleton. As you can see, Extract Skeleton from IK Object is a nifty skeleton copy tool.

With the Add New Bone tool you can create individual bones and use them to build a skeleton. You can then attach the bones to each other using the Add Custom Joint tool by clicking each of the bones.

The third choice, the Build Skeleton tool, is the one you will most likely use to construct your bone structures for your characters. The Build Skeleton tool makes it possible to construct a skeleton directly in 3D space or inside an object.

You can use the Build Skeleton tool to create a whole new skeleton from scratch, edit an existing skeleton, or make changes to a skeleton that has been skinned. Once in Build Skeleton mode, you can manipulate or delete existing joints, or add more joints and bones to the skeleton. To exit the Build Skeleton mode, click the Build Skeleton

tool again.

If a object that has had a skeleton attached is selected, clicking the Build Skeleton tool reverts the skeletal structure to its original state when it was attached to the skin. All the keyframes associated with the bone structure (skeleton) will be deleted.

You can construct your skeleton in an orthogonal or perspective view window. In the Perspective view, if there is no object under the cursor while placing bones and joints, the skeleton will be built in the X-Y plane parallel to the Grid. In a orthogonal view, it is built in a plane perpendicular to the selected view[md]Front, Left, or Top. If there is an object under the cursor, however, the skeleton is built inside of that object.

Let's take a closer look at the Build Skeleton tool and the panels associated with it.

The skeleton panels are vital in the creation of a workable skeleton that can be applied to a character. There are two panels involved, the Build Skeleton panel and the Build Skeleton Properties panel, as shown in Figure AB.1.

Figure AB.1 - The Build Skeleton and Build Skeleton Properties panels.

The Build Skeleton Panel
You will spend a lot of time in the Build Skeleton panel when constructing skeletons or what I like to call bone structures. The Build Skeleton panel consist of six buttons and three check boxes. Here is a rundown of each.

Move Joint
Clicking and dragging on a joint moves the individual joint. If the Add Joint tool is active (button depressed) the newly created joint can be immediately moved as long as you don't release the mouse button. When the Move Joint button is activated, holding down the Ctrl key while dragging a joint moves the branch which makes up the joint and the two bones connected to it. This has the same effect as enabling the Move Branch option in this same panel. You will grasp this better with a short exercise.

Step 1. Open a new scene and Switch to the Front view. Click the Build Skeleton tool to open the Build Skeleton panel.

Step 2. Click in the lower-left corner of the workspace. Working your way up to the upper-right corner, left-click five times.

Step 3. Deselect the Add Joint button in the Build Skeleton panel. If

for some reason the Move Joint button isn't depressed, click it now.

Step 4. Select the center joint and drag it up and down. Notice the rubber band effect as you move the joint. Release the joint and press the Undo button.

Step 5. While pressing the Ctrl key, reselect the center joint and move it as you did before. Notice anything different about the Bones movement? The entire branch moves instead of just the joint and two bones attached to it.

Move Joint is extremely handy when you want to resize a bone that is part of a branch without affecting any of the other bones. This has the same effect on an attached Bone and its size as enabling the Move Branch option. I find that using the Ctrl key is easier to work with and it's nice not having to remember to disable it when your done, just release the Ctrl key.

Add Joint and Add Branch
Add Joint creates a new joint and adds a bone connected to the most recently added branch of the skeleton (bone structure). Here is the neat part: By clicking on an existing bone with the Add Joint tool active, a new joint is created dividing the existing bone in two.

When Add Branch is checked, a left-click with the Add Joint tool active adds an extra joint to the bone nearest the cursor. If the nearest bone is a leaf bone the new joint will become attached to the Leaf Bone's end. The new joint becomes the active branch. That means if the Add Joint tool is enabled as well joints and bones will be added from this new branch. This is interesting, let's try it out.

Step 1. Open a new scene and Switch to the Front view. Click the Build Skeleton tool.

Step 2. The Add Joint button should be depressed as well as the Move Joint button. Click in the lower left corner of the workspace. Working your way up to the upper right corner left-click three times.

Step 3. Click the area between the middle joint and the first joint. A new joint should appear splitting the bone in half. Let's try adding a branch.

Step 4. Select the Add Branch option in the Build Skeleton panel.

Step 5. Click anywhere above the bone structure in between two joints. Be sure not to click on any of the bones. A new branch should appear attached to the center of the closest bone where you clicked.

Normally if the Add Branch option was disabled and you clicked outside the bone structure a new joint would have been added in that spot with a bone leading back to the last joint that was selected.

The Add Joint and Move Joint functions can be used together (enabled/disabled), to prevent moving a joint when you want to add a joint or from adding a joint when you want to move one.

Move Branch

When Move Branch is enabled, clicking and dragging on one joint in a branch moves all joints from the selected joint away from the nail in tandem. Remember, while the Move Joint tool is active, holding the Ctrl key while dragging a joint does the same thing as the Move Branch Option without having to remember to disable it.

Delete Joint
In the last exercise, we added new joints to a skeleton. Let's assume that we didn't want one of the joints in our new bone structure. This is where the Delete Joint tool comes in. When Delete Joint is active, clicking on a target joint deletes it. trueSpace4 then reverts to Add Joint mode. If the joint you want to delete was created as the last operation, selecting Undo will accomplish the same thing.

Edit Joints Directly
The Edit Joints Directly button allows you to edit the joint rotation and constraints directly. Clicking this tool will display the joint's control handles. They appear as a circular object resembling the Pac-Man video game character in the center of the joint called the joint's radial indicator, which is used to adjust a joint's pitch, roll, and yaw. (See Figure AB.2.) In plain English, it's a wonderful device for adjusting the resistance to rotation and the amount of free movement (swing) the attached bones will have.

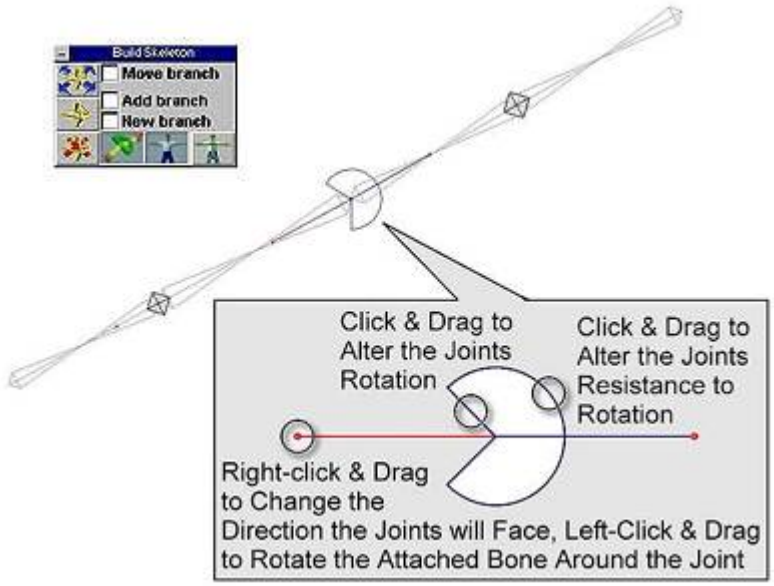


Figure AB.2 - You can interactively change the pitch, roll and yaw of a joint via the joint's control handles.

Let's take this opportunity to discuss rotating joints and controlling the swing of the bones attached to the joint.

Step 1. Open a new scene, and Switch to the Front view. Click the Build Skeleton tool.

Step 2. The Move Joint and Add Joint buttons should be depressed. Click in the lower-left corner of the workspace. Working your way up to the upper-right corner, left-click three times.

Step 3. Click the second joint. This makes it the active joint.

Step 4. Click the Edit Joints Directly button. The joint's radial indicator should appear as depicted in Figure AB.2.

Step 5. Select the outer edge of the radial indicator. Drag your mouse out and away from the joint. This controls the resistance to rotation. The larger the value, the more resistance, making it harder to move the bones attached to this joint.

Step 6. Select either of the two handles that run from the outer edge of the radial indicator to its center (where a piece of pie looks like it has been cut from it). If you drag your mouse you can define the degree of rotational freedom the attached bones will have.

Step 7. Right-clicking the far end of either of the two control handles running through the center of the radial indicator and dragging your mouse will rotate the joint. If you left-click and drag this area the bone attached can be moved.

As you can see, working with trueSpace allows a lot of freedom. Now on to two very interesting buttons.

Build Skeleton
Inside Skin and Link IK Object Build Skeleton Inside Skin is a toggle button. When the Build Skeleton Inside Skin button is depressed, the Link IK Object button is disabled. The Build Skeleton Inside Skin tool is the default mode of building a skeleton and allows you to build the skeleton freely by adding joints anywhere in the workspace, a different approach to what Link IK Object does.

When enabled, Link IK Object disables the Build Skeleton Inside Skin button. It allows the creation of a skeleton from an object with hierarchies. To use this tool, select the object made up of glued parts and enable the tool. Click one of the subobjects belonging to the hierarchical object. The tool finds the two closest objects and links them with a joint.

If it seems as though this is a lot too absorb at first don't worry, you will have a chance to use many of the Build Skeleton panel's tools in the upcoming exercises. Now, let's look at the second panel.

The Build Skeleton Properties Panel
Right-clicking the Build Skeleton tool opens the Build Skeleton Properties panel (as well as the Build Skeleton panel). This panel (in my opinion) is where you separate the well built skeletons from the weak, hard-to-work-with kind. The first item on the panel is the Link With button. This is where you choose which kind of joint to use when constructing your skeletons. The Caligari documentation states basically this:

Link with: Use this pop-up menu to determine the type of joint to be used by the Build Skeleton tool. The default type is 1D Hinge. You can adjust the properties of a joint at any time using the Edit Joints Directly tool in the Build Skeleton panel."

That is a generic statement that doesn't tell us much. It doesn't

mention that this is the secret to good skeletal motion. That it is the most important button in the whole mix of Bones tools. Here is my take on this panel. Follow along with me in Figure AB.3.

When constructing your skeletons, keep the Build Skeleton Properties panel open. As you construct your skeletons you will want to switch to different types of joints at different points of the construction process. For example, take the human arm, starting at the wrist a 2D Spherical Joint would be used because our wrists rotate in two directions. At the elbow a 1D Hinge Joint should be used because our elbows swing in one direction (with a limited amount of movement). Our arms swing at the shoulder basically in two directions, so a 2D spherical Joint should be used at the shoulder. If you were to use the default 1D Hinge Joint throughout the skeletal build process you will find that your character becomes difficult to pose naturally.

So, a rule of thumb should be to keep the Build Skeleton Properties panel open during the skeletal build process. We will discuss selecting the right joint a little later in this chapter for now let's continue to look at the other items in the Build Skeleton Properties panel.

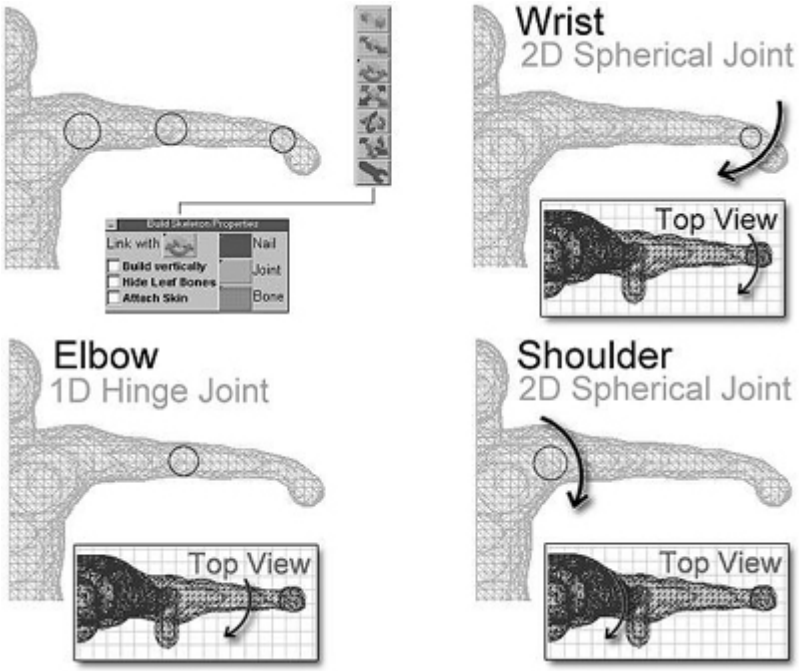


Figure AB.3 - Two types of joints should be used when creating a skeleton for a humanoid character.

Build Vertically: This option only pertains to the Perspective view. Use this option to build the skeleton from the ground up (or vice versa). With this item unchecked, the bones will be placed parallel to the ground.

Hide Leaf Bones: A joint links two bones. One or both of these bones can act as a leaf bone. A leaf bone isn't connected to other bones. The direction the leaf bone will face is extrapolated from the direction of the previous bone. You can hide leaf bones during the skeletal build process by clicking Hide Leaf Bones in the Build Skeleton Properties panel. If the leaf bones are visible, you can alter their direction by clicking and dragging the unattached end. If you hide the leaf bones,

they will appear after exiting the Build Skeleton mode.

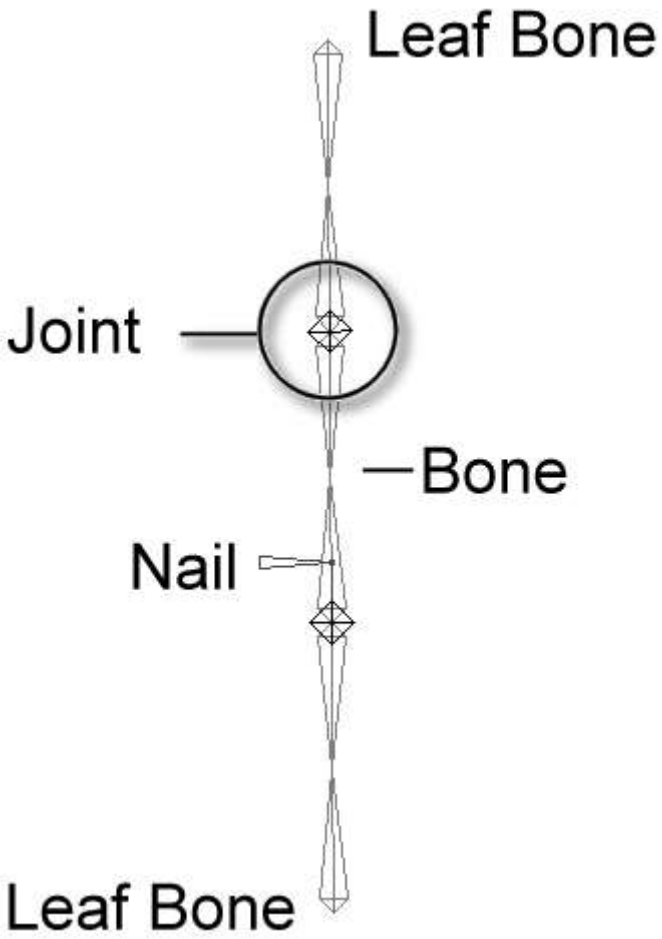


Figure AB.4 - The anatomy of a simple skeleton (bone structure).

Nail, Joint, and Bone Color: These three buttons allow you to choose a color for the three visible elements of a skeleton, the nail, joints, and bones. Click and hold the color buttons to view a popup menu with a selection of colors to choose from.

That just about covers the panels. As I promised, now that the panels are out of the way we can actually construct a skeleton for a bipedal humanoid character.

Creating a Bone Structure for Bipedal Humanoids
Let's put the skeleton panels to work. For this next exercise we will construct a skeleton for the superhero character we built in Chapter 4. Before you tackle this exercise please review figure AB.4. Get familiar with the names of these basic components of a skeleton because I will refer to them throughout this chapter.

Step 1. Load the AniHero.scn (Get It) file located on the resource CD. You might remember this guy from the character modeling tutorial. He was created using trueSpace metaballs. I converted him into a solid polyhedron for this exercise.

Step 2. Right-click the Build Skeleton tool to open the Build Skeleton

panel and Build Skeleton Properties panels.

Step 3. We are going to start with the head of the character and work our way down creating the character's spine. Can you guess what kind of joints should be used for the character's spine? If you said 2D Spherical joints, you are correct. In the Build Skeleton Properties panel, set the Link With option to a 2D Spherical Joint. In the Build Skeleton panel make sure the Move Joint and Add Joint options are enabled (depressed) as well as the Build Skeleton Inside Skin button. I like a clean workspace free of unnecessary clutter, so click the Hide Leaf Bones option in the Build Skeleton Properties panel.

Step 4. Starting with the character's head, click the top of the skull and click at the neck. This will create one bone that extends from the top of the skull to the neck. Try to keep the joins lined up vertically.

Step 5. To complete the character's spine, click the center of the chest, the center of the abdomen, and the crotch area where the legs meet. Figure AB.5 illustrates the locations.

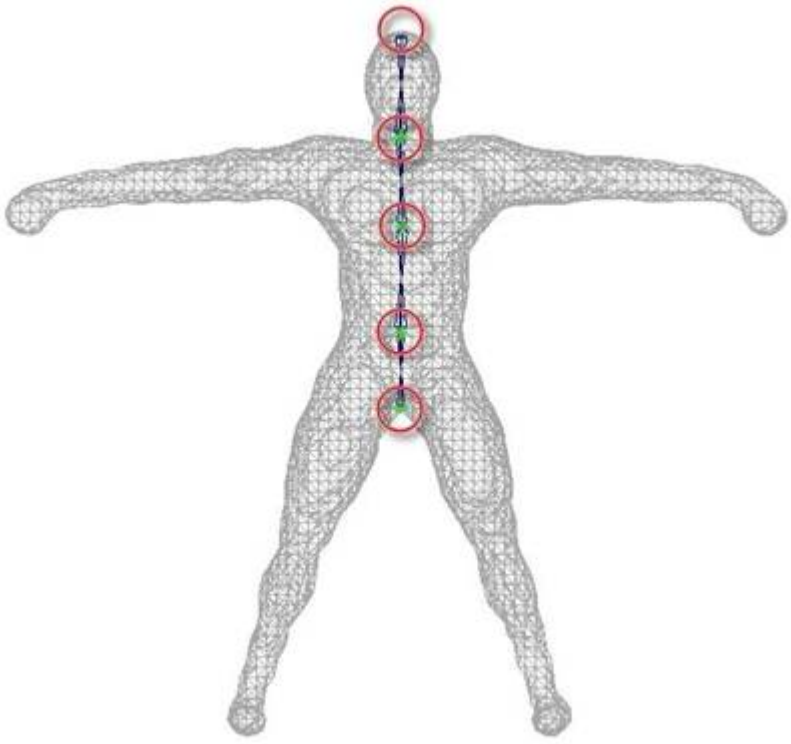


Figure AB.5 - The locations of the 2D Spherical joints that make up the character's spine.

Step 6. For the arms we will have to create two branches to create the shoulders. In the Build Skeleton panel, click the Add Branch option. Click on the left side of the second bone (from the top) near its center. This should add a branch to the second bone to form the left shoulder. Click on the right side as you did before to form the right shoulder. Click the Add Branch option in the Build Skeleton panel to disable it.

Step 7. The joints that make up the shoulder need to be moved into place. To do this without adding unnecessary joints, disable the Add Joint button in the Build Skeleton panel. Click the left shoulder joint and drag it near the top of the shoulder where the arms connect to the

torso. Do the same for the right shoulder. Enable the Add Joint button in the Build Skeleton panel.

Step 8. Up to this point, we have used 2D Spherical joints for the spine and shoulders. For the character's elbow we need to change the type of joint from a 2D Spherical joint to a 1D Hinge joint because elbows swing 90 degrees in one direction, any other type of rotation would be painful. In the Build Skeleton Properties panel, set Link With to 1D Hinge Joint.

Step 9. Starting with the arm on your left (character's right arm), click where the elbow should be. A guess is okay. You can move the joint later if you need to. To construct the character's left elbow (on your right) click the center of the joint that makes up the character's left shoulder. This won't do anything at this point. All you have done is make that joint the active joint. Unfortunately, there is no way to tell if a joint is the active joint. Click where the character's left elbow should be.

Step 10. For the remainder of the character's arms we will need to change the type of joint from a 1D Hinge joint to a 2D Spherical joint because our wrist rotates along more than one axis. In the Build Skeleton Properties panel, set Link With to 2D Spherical Joint.

Step 11. Click the wrist area of the character's left arm (your right) remember, that the left elbow was the last joint we added therefore it should be the active joint. To finish the character left arm, click the end of the character's fist. For the character's right arm, click the character's right elbow to make this joint the active joint. Click the right wrist and the tip of the right fist. Use Figure AB.6 as a guide.

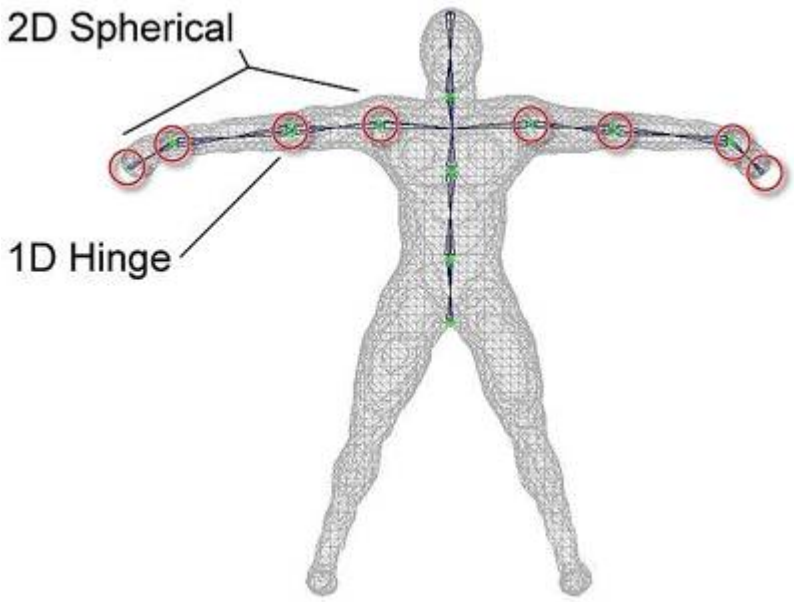


Figure AB.6 - The location of the joints that make up the character's arms. The character's
shoulder and wrist are 2D Spherical joints while the character's elbow is a 1D Hinge joint.

Step 12. Creating the hips of the character will require a branch at the last bone of the spine. In the Build Skeleton panel, click Add Branch.

Click the left side of last bone of the character's spine near its center. This will create the branch where the thigh bone and waist will meet. Disable the Add Joint button and Add Branch option in the Build Skeleton panel. Click the newly created joint and drag it where the thigh and torso meet. Click and drag the last joint in the spine and place it where the character's left thigh and torso meet.

Step 13. To create the character's knees and ankles we will need to change from the present 2D Spherical joint to a 1D Hinge joint. In the Build Skeleton Properties panel, set Link with to a 1D Hinge Joint. In the Build Skeleton panel, enable the Add Joint button.

Step 14 . Click the knee, the ankle, and the bottom of the character's foot to complete the character's left leg. Click the joint in the character's right hip to make it the active joint. Repeat the previous steps clicking the knee, the ankle, and the bottom of the character's right foot to complete the character's skeleton (bone structure). Take a look at Figure AB.7 to see the finished character's skeleton.

Step 15. Click the Object tool to close the Build Skeleton panel.

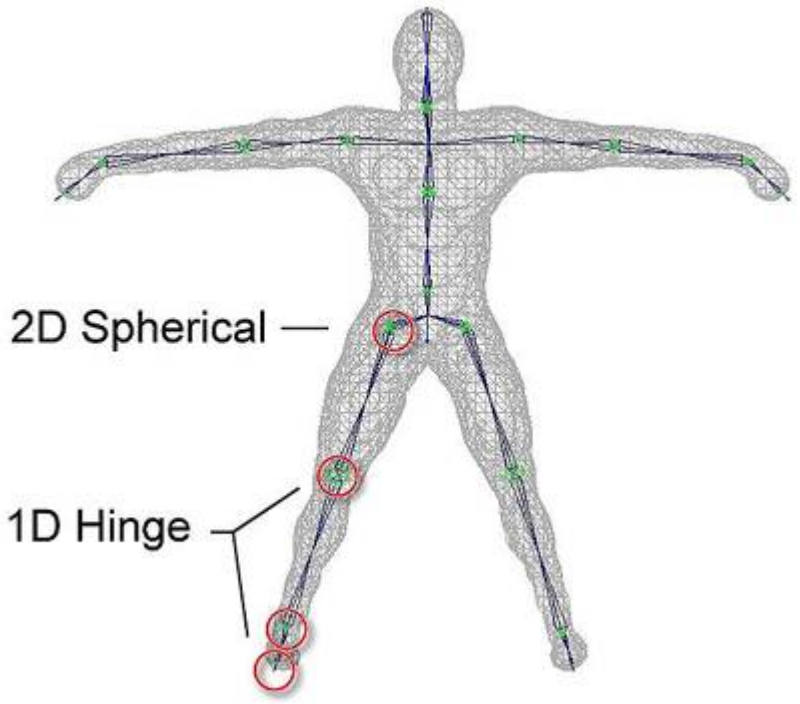


Figure AB.7 - The complete skeleton. The character's legs consist of a 2D
Spherical joint at the hips and a three 1D Hinge joints for the knees and ankles.

Always Test Your Work
That covers creating the basic skeleton but it isn't ready to be attached to an object just yet. We have to test our bone structure before attaching it to a character. Save the scene locally on your drive and call it HeroBones.scn. During the next few steps if anything flakes out on you simply reload the scene and start over. In the next discussion I will refer to parts of the skeleton as belonging to the character. What I am referring to is the area of the character mesh where a joint or bone is located. Because we haven't attached the skeleton to the character

yet the two are still separate individual objects.

In the animation pre-cursor tutorial we briefly discussed bones and we practiced using the nail. If you are familiar with using the nail go ahead and skip this paragraph. For those of you that may have skipped ahead, let me recap. The nail is used to anchor a bone so you can manipulate the other portions of the bone structure. You can move the nail by dragging it onto a different bone.

When creating characters that will be later animated with bones it is best to model the character in the "neutral pose" prior to building and attaching bone structures to your character's. This makes the attaching skin to bones easier and eliminates vertices from different parts of body becoming attached to a limb. The neutral pose is depicted in Figure AB.7.

What I would like you to do now is drag the nail to the character's waist. With the skeleton's center of gravity anchored click the left or right fist and manipulate the skeleton. Bones uses inverse kinematics so moving the character's fist should move the forearm which moves the bicep, which pulls at the character's shoulder's making him bend at the waist. When you're done fooling around, click Undo to restore the skeleton to its original pose.

The reason I had you do this is to get a feel for how the joints are orientated. By manipulating the skeleton before attaching it to an object we can check the orientation of the joints and make any adjustments necessary. This is good practice and can save you some headaches later.

Reset the skeleton to it's original position (pose) by clicking Undo. Let's take a look at the joints of our bone structure and how we can manage their placement, orientation, resistance to rotation and the freedom of movement of the bones attached.

Editing Joints
You can use the Build Skeleton tool to edit a joint's degrees of rotational freedom by double-clicking on any joint to display its control handles. You can use the Pitch, Roll, and Yaw indicators to change the degree of freedom for the selected joint. To adjust the Min/Max values for the selected joint, click directly on the radial indicator and swing the joint around to set Min/Max to the new values. When you release the mouse button, the branch will return to its previous position. You can display the properties of any other joint simply by clicking on the desired joint. A second double-click will exit Joint Edit mode.

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Step 1. Switch to the Top view and zoom in on the character's right arm keeping the shoulder to the fist within the view window.

Step 2. Right-click the Build Skeleton tool to open the Skeleton panels. In the Build Skeleton panel, click the Edit Joints Directly button. Click the elbow joint to reveal the joints control handles. You may notice that the elbow joint doesn't seem to have a radial indicator to adjust the joint's pitch, roll, and yaw. It's there, but it's facing the wrong way. To correct this problem, right-click the tip of the red control handle and drag your mouse until the joint rotates 90 degrees revealing the radial indicator.

Step 3. Select the Object tool to complete the operation. Now for the test, if we positioned the elbow joint correctly the forearm should swing vertically in the Top view. Open a smaller window and set it to the Front view. Position the view so that the whole character is visible. Click and drag the nail from its current position to the bone that runs through the character's right bicep. If you attempt to do this and the eye of the camera moves, select the Object Move tool then try it again. Close the smaller view window when done.

Step 4. In the large view window, select the bone in the character's right fist and drag your mouse down towards the bottom of the screen. The bones that make up the forearm should move freely. Click Undo and drag the fist towards the top of the screen. Ouch! That isn't natural is it? Our arms do not bend in that direction. Let's fix it and while we are at it let's adjust the amount of resistance the forearm has to movement.

Step 5. Click Undo to reset the forearm to its original position. Right-click the Build Skeleton button to open the Skeleton panels if they aren't already open. In the Build Skeleton panel, click the Edit Joints Directly button. Click the elbow joint to reveal the joint's control handles and radial indicator.

Step 6. The radial indicator at the center of the joint has two functions. The first is it can be used to adjust the amount of resistance the attached bones will have to rotation. You change its value by clicking and dragging on its outer surface. The radial indicator control handles will change color when under your cursor control. A larger value (larger size) creates more resistance and therefore it takes more force to rotate the forearm. Go ahead and increase its size, not too much. You want to be able to swing the character's arms. The second function the radial indicators provides is it can be used to limit the degree of movement. In our case, we want to limit the forearm from bending backwards. To adjust the amount of freedom the forearm has to swing, click and drag either of the two control handles that connect the outer surface of the radial indicator and its center. In our case we are concerned with the top one. Click and drag it, you will notice that the forearm follows the control handle. This is what's so wonderful about trueSpace, its feedback is above par. Drag the control handle until the forearm is parallel to the character's arm.

Step 7. Select the Object tool to close all the panels. Click and drag the character's right fist up towards the top of the screen. It won't budge and unlike you can with the human elbow, you can't force it. Click and drag the fist down towards the bottom of the screen. The arm bends but with a little more resistance than before. If you are

having a hard time bending the arm at the elbow it is probably because you set the elbow joint's resistance a bit too high in the previous step. You will have to go back and edit the joint directly and decrease the joints resistance to rotation.

Not all the joints will be out of whack but you should check each to insure that the bones will react as expected. If it helps delete or move the character mesh out of the way so you can see the joints better. Remember to use the nail to limit movement to specific areas while testing your joints.

You do not have to use a combination of 1D Hinge and 2D Spherical joints when constructing skeletons for your characters. You can use 2D Spherical joints for every joint in your character, but you will have to set each of the joint's degree of freedom accordingly via its radial indicator. The orientation of the joints are totally dependent on the type of character you are working with.

When you have the skeleton to your liking, select the skeleton and click the Attach Skin to Skeleton tool. Your mouse cursor will change to a glue bottle. Select the character's mesh. After a few seconds the character can be posed using trueSpace bones. Select the Object tool to end the process.

As you can see there are a few details involved in setting up a workable skeleton in trueSpace. After you have built a few you should be able to create a skeleton in just a few minutes.

You can adjust any of the joints of a skeleton after it has been attached to an object in the same manner as performed above by right-clicking the Build Skeleton tool.

We have created a bone structure and edited the joints of the bone structure, now let's look at what's involved with attaching an object's skin to a skeleton. When we are done we will get into trueSpace's tendon and muscles features.

Attaching Skin (An Object's Mesh) to a Skeleal Structure
The Attach Skin to Skeleton tool makes it possible to attach an object (skin) to a skeleton to aid in animating your characters. trueSpace automatically assigns parts of the skin surface to the skeleton to form muscles and tendons. You can later edit the degree of influence a muscle or tendon has on a particular bone if needed. You can attach a skeleton to a single object or to a group of objects that are glued together. You can also attach a skeleton to several objects at once which can overlap each other. Portions of the skin that extend beyond a leaf bone are deformed along with the surface that is attached to this bone.

The skeleton does not have to be completely contained within an object. Bones can extend outside the object they are attached to.

The skin surrounding a bone between two joints forms one muscle. This muscle can be the contractor with respect to either of the two joints, but it cannot be the contractor for both joints simultaneously. We will discuss the contractor muscle further shortly.

It may be a little confusing at first but the muscle performing the bulge is considered the contractor muscle. It is being contracted, to shrink by drawing together.

On a branch bone (a bone that has more than two joints linked to it), the portion of the skin that encloses the bone is divided into as many muscles as there are joints. Each of these muscles can be a contractor for a corresponding joint.

The Attach Skin to Skeleton tool also allows you to separate the skin from the skeleton so that you may change the position, rotation, or size of the skeleton within the skin. When the Attach Skin to Object tool is active, you can click and drag the selected object to move it into position. If the skeleton is dragged completely away from the skin, the skeleton will become detached, allowing you to edit the skin (object) without interference from the bone structure. Here's a step-by-step look at some common Attach Skin to Skeleton procedures.

To attach a skeleton to an object:

Step 1. Select the skeleton.

Step 2. Click the Attach Skin to Skeleton tool. The cursor will turn into a glue bottle.

Step 3. Click the target object (skin).

Step 4. Click the Attach Skin to Skeleton tool again, or click the Object tool to exit the Attach Skin to Skeleton tool.

To detach a skeleton from its skin:

Step 1. Select the object that has been assigned a bone structure.
Step 2. Click the Attach Skin to Skeleton tool.
Step 3. Hold down the Ctrl key and click, or you can hold the Ctrl key and drag the skin outside the skeleton.
Step 4. Click the Attach Skin to Skeleton tool, or click the Object tool to exit the tool.

To re-orient or resize the skin:

Step 1. Select the object that has been assigned a bone structure.
Step 2. Click the Attach Skin to Skeleton tool and select Object Scale, Object Move, or Object Rotate. You can now move, rotate, or scale the skin as you would any other object.
Step 3. Click the Attach Skin to Skeleton tool, or click the Object tool to exit the tool.

Once the skin has been attached to the skeleton, you can begin to deform the object's mesh (skin) by clicking and dragging on any part of the skin surface. You can also place the nail anywhere on the skin to anchor that portion of the object.

We will revisit bones again in the next tutorial "Character Animation" when we animate Frankie our little skate boarding terror but first we

must learn how tendons and muscles are used.

Once you have created a bone structure for your character you can edit the degree of muscular contraction of your character's limbs. trueSpace4 has a full compliment of tools that allow you to visually edit the muscles and tendons of your characters. (See Figure AB.8.)

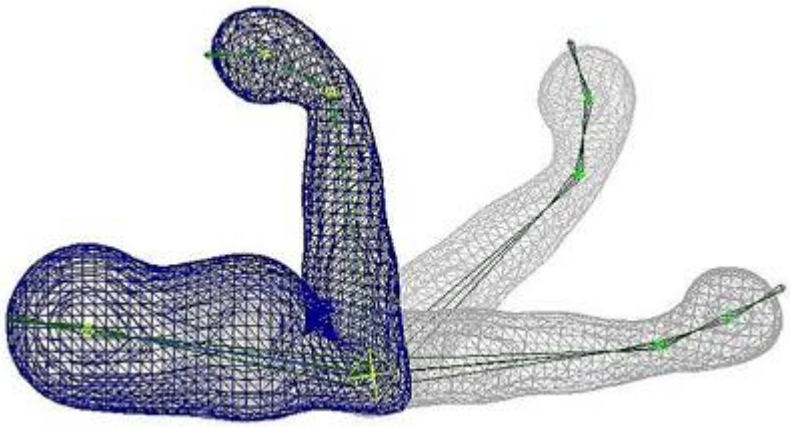

Figure AB.8 - You can add impressive muscle bulges to your character's with the Muscle and Tendon tools.

Editing Tendons
The Edit Tendons tool allows you to change the Tendon Rate of the selected joint. When clicked, the bones structure will revert (temporarily) to its original position (pose) when the skin was first attached. You will also see two planes that define the selected limits of influence of the selected tendon. Click on the control handle below the selected tendon and drag right to increase the Tendon Rate, drag left to adjusts the proportions between the tendon and the muscle. To select a different tendon click on a different joint.

The Skinning Panel
Right-clicking on the Attach Skin to Skeleton tool or the Edit Tendons tool opens the Skinning panel which is used to control how muscles and tendons are assigned to the skin. Let's review this panel and each of its options.

Tendon Rate: Adjusts the proportions between the tendon and the muscle. Higher values increase the influence of the tendon, the area between the two planes depicted in Figure AB.AB. The arm at the top of Figure AB.9 has a tendon rate of 0.07, the one below it has a Tendon Rate of 0.20. Notice how the planes visually define the area of the tendon. The Tendon Rate can also be adjusted by clicking on the control handles that appears just below the selected tendon. The acceptable range is from 0.01 to 0.9AB. The default value is 0.20.

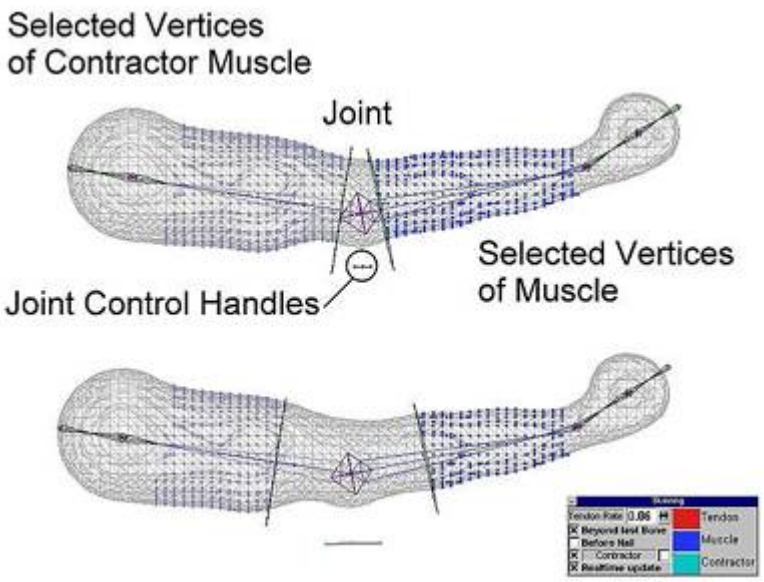

Figure AB.9 - A model of a character's left arm. Once the bone structure was assigned to the object,
clicking the Edit Tendons tool opens the Skinning panel. Clicking the elbow joint displays
the muscle, contractor muscle and their influence on the character's mesh.

Beyond Last Bone: When checked, any area of the skin that is beyond a leaf bone is attached to the selected bone. Otherwise, that portion of the skin will remain immobile. By default this is selected.

Before Nail: When enabled, any area of the skin that does not enclose any bone is attached to the bone that has the nail attached. By default this is selected.

Contractor: Switches which muscle will act as the contractor. On either side of the word Contractor are two check boxes, if you wish to swap the muscle and contractor muscle click the opposite checkbox.

Realtime Update: This option is primarily used to disable the visual feedback of Tendon Rate. With this option disabled, only the planes representing the tendon's edges will be updated on screen. The update to the skin, tendon and neighboring muscles will be performed after the mouse button is released. This is checked by default.

Tendon, Muscle, and Contractor Color: Provides a choice of six colors for identifying the vertices of the tendon. The default color is red.

Now that we have looked at trueSpace tendons let's look at trueSpace muscles.

Editing Muscles
To edit the muscles of your object, left-click the Edit Muscles tool. This will place trueSpace4 in Muscle Edit mode and will open the Muscle Properties panel. When you first use the Edit Muscles tool, the first muscle from the nail will be selected, otherwise, the vertices of the last bone you edited will become highlighted. You can select another

muscle by clicking near the desired bone.

The vertices of the muscle contractor will become highlighted and a small control handle will appear above the muscle. This control handle may or may not be visible depending on the object you are working with. So, in the up coming exercise we will use the Muscle Properties panel to make any adjustments, but for the sake of clarity let's go over the Muscle Properties panel, the control handle, and its hot spots.

The Muscle Properties Control Handles and Panel
Left-clicking the Edit Muscle tool opens the Muscle Properties panel and places trueSpace in Edit Muscle mode. A control handle will appear above or below the selected area, either a tendon, muscle or muscle contractor.

The center point: Adjusts the volume of the muscle bulge (strength). A numeric value can be manually entered in the Strength field located in the Muscle Properties panel. To use the control handle, click and drag your mouse left to extend the bulge, drag right to decrease the bulge.

When adjusting muscle settings you should have the muscle you will be working with contracted. This way you can see some visual feedback as you make your adjustments.

The handles parallel to the bone: Adjusts the strength along the bone. (I prefer to call this the muscle tone setting, I will show you what I mean in a second.) You can enter a numeric value in the Length field located in the Muscle Properties panel. To use the control handle, click and drag your mouse right to widen the muscle bulge from the muscle's center outward along the bone, drag left to reduce this value. Let's look at an example of this effect.

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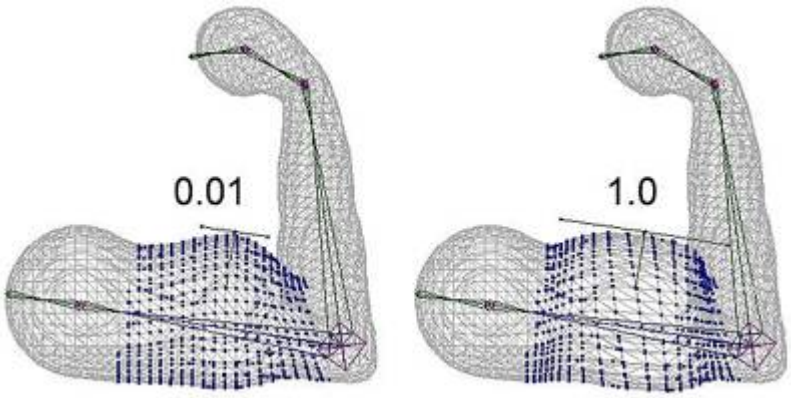

Figure AB.10 - Adjusting the muscles length along the bone separates the muscles vertices around its center. I like to refer to this setting as the muscle tone setting. Notice how the muscle flattens out with a higher setting.

Handle perpendicular to the bone: Adjusts the width of the muscle bulge. You can enter a numeric value in the Width field located in the Muscle Properties panel. Click and drag your mouse to the right to increase the muscle's bulk perpendicular to the bone, drag left to make the muscle less bulky. The difference can be seen in Figure AB.11.

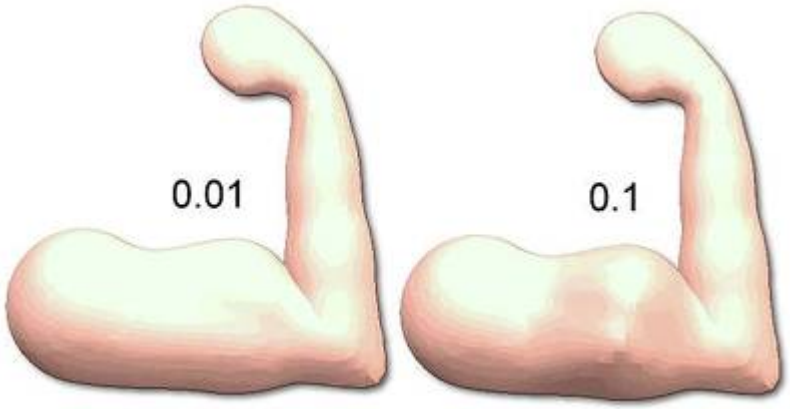

Figure AB.11 - Increasing the width of the muscle makes the muscle look more bulky and more impressive.

The handle extending toward the bone: Adjusts the falloff of the muscles bulge. A low falloff value causes wider muscle bulging. A large value creates a sharper bulge. Right clicking on the control handle turns the muscle into a bi-directional flexor/extensor type. A blue and red line indicating the direction of the contraction will appear running through the muscle. Dragging the line on either the red or blue side will change the direction of muscle flex.

While in this mode, the flexor and extensor get their own separate set of the parameters described above, allowing you to specify independent values for each. Only one of them can be contracted at a time, and the flexor/extensor line will adjust the parameters of the contracted part of the muscle. To reset the muscle to omni-directional right-click on the control handle again. You can also set this with a checkbox in the Muscle Properties panel. The Flexor/Extensor checkbox allows switching between all-directional and bi-directional contraction of the muscle. Figure AB.12 illustrates this setting.

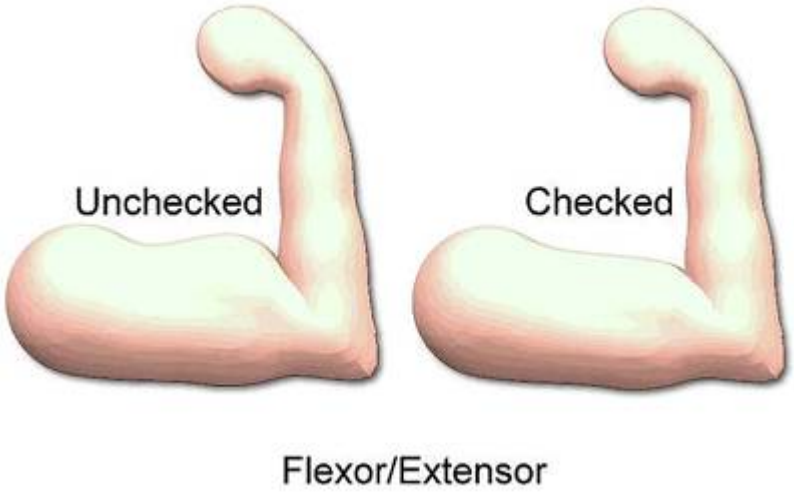

Figure AB.12 - In this image the results of setting the Flexor/Extensor

option are visible.
As you can see, with this option unchecked the muscle bulges.

Sharpness: This is related to the joining tendon. Clicking on or near a joint will select a tendon. A small control handle appears above or below the tendon. Use this setting to adjust the sharpening of the tendon when bent. Figure AB.13 illustrates this.

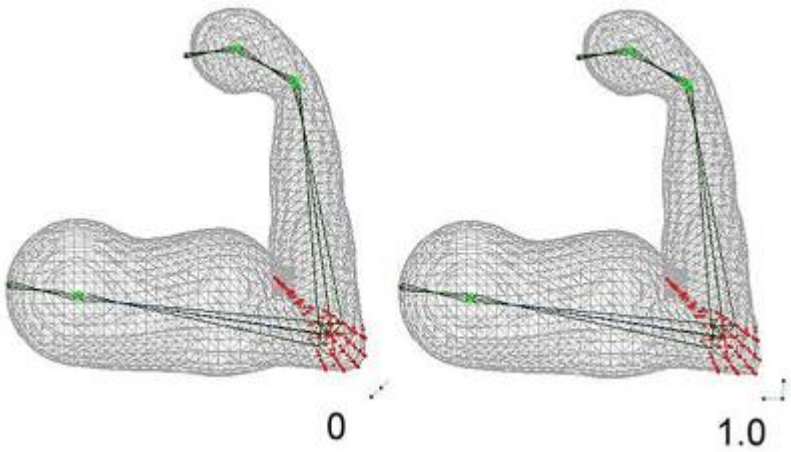

Figure AB.13 - In this image the tendon sharpness setting is visible around the character's elbow.

Muscle Exercise
To get your characters muscles to bulge realistically you must learn how the relationships between muscles, tendons, and muscle contractors affect the objects attached to a skeleton. In the above discussion we covered a lot of ground and through illustrations saw how the muscle and tendon settings affect the muscle bulge. It's now time to put this information to some practical use. For our next exercise we will add a bone structure to a character's arm and adjust the tendon and muscle settings. When we are done you will be able to flex the character's arm and see its muscles bulge. Let's get started.

Step 1. Open the file names HeroArm.scn - Click here to download it. The arm used in the previous illustrations will appear in the Front view window.

Step 2. Click the Build Skeleton tool, this will open the Skeleton panels.

Step 3. For this exercise we will only use 1D Hinge joints for the arm. Near the edge of the fist click once. Continuing down the arm to the shoulder click the center of the fist, the wrist, near the elbow area, and the center of the shoulder area. This will create the basic skeleton we will need to flex the arm realistically. Use Figure AB.14 as a guide.

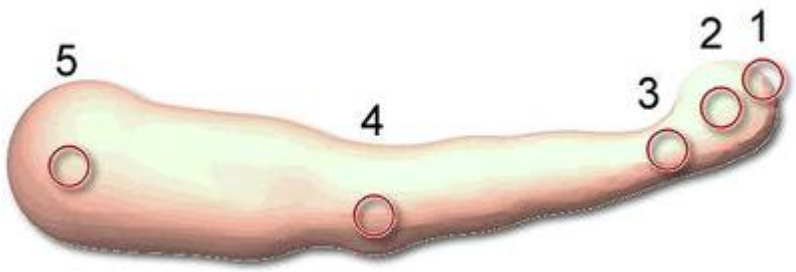

Figure AB.14 - The five areas of the arm you should click to create the arm's bone structure.

Step 4. Click the Attach Skin to Skeleton tool. Your cursor will change to a glue bottle, click the arm mesh. A dialog box will appear warning you that you are about to delete a metaball structure, click yes to convert the arm (created with metaballs) to a polyhedron.

Step 5. Click the Object tool to exit the Attach Skin to Skeleton tool. The skeleton and mesh should be both appear to be selected.

Step 6. Click the nail and drag it to the bone in the bicep. Select tip of the leaf bone sticking out of the fist and drag it to the shoulder in an arch over the arm. The arm doesn't bend realistically and the bicep muscle doesn't bulge like I illustrated earlier because only the bone structure and joints have been defined so far. We need to tell trueSpace what the joints limitations as well as how we want the muscle and tendons to be defined.

Step 7. Click the Build Skeleton tool to open the Build Skeleton panel. Make sure the Add Joint button is disabled. Double-click the elbow joint to enter Joint Edit mode. The joint's radial indicator will appear.

Step 8. Select the top control handle that runs from the center of the radial indicator to the radial indicator's outer surface and drag it until the forearm points straight up. Release your mouse, the forearm will revert back to its original position. Click and drag the lower control handle until the forearm is horizontal, similar to its present position. These two actions will limit the forearm's swing as we manipulate it later during this exercise.

Step 9. Click the wrist joint and perform the same operations as you did for the elbow joint. Set the wrist joint's rotational limits close to your own. Make a fist and study how far it bends, do the same for the character's arm. When you're satisfied with the wrist joint click the Object tool to exit Edit Joints mode. Click and drag the tip of the leaf bone exiting the fist as you did before. It should bend more realistically now that you have defined the joints rotational limits. When you're done click Undo to reset the arm to its original pose.

Step 10. Click the Edit Tendons tool. The vertices that define the contractor muscle and the muscle will change color. You can change the color of each by right-clicking the Edit Joint tool. Click and drag the control handle below the elbow joint to your left until the two planes move in close to the elbow joint as depicted in the top half of Figure AB.15.

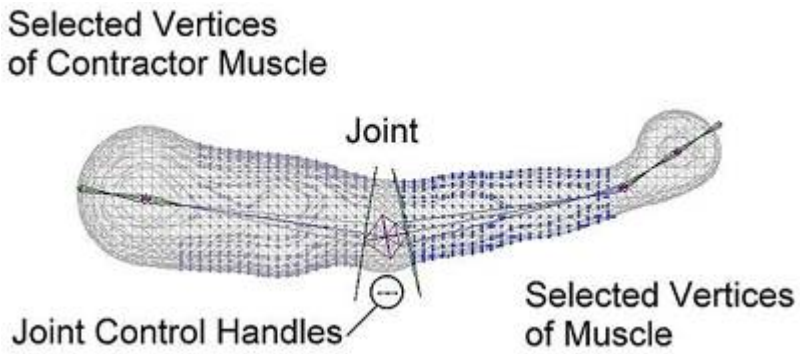

Figure AB.15 - Using the Edit Tendons tool make the arm bend at the elbow more naturally.

Step 11. Click the wrist joint and draw the two planes in towards the joint as you did with the elbow joint. Click the Object tool. Click and drag the leaf bone (exiting the fist) left until the forearm won't move any more.

Step 12. Click the Edit Tendons tool (don't panic, the arm will be temporarily straightened during this operation) and then right-click it to open the Skinning panel. In the Tendon Rate field enter 0.06. Close the Skinning panel.

Step 13. Left-click the Edit Muscle button to open the Muscle Properties panel. Click on the center of the bone running through the bicep. Drag the center of the bone up to the shoulder near the shoulder joint. This will provide us with only one set of vertices to worry about.

Step 14. In the Muscle Properties panel enter 0.1 in the Strength field, 0.1 in the Length field, 0.2 in the Width field. Use these setting as a starting point when working with muscles. Click the Object tool to close all the panels.

Step 15. Click and drag the tip of the leaf bone that exits the fist left and right. The character's bicep muscle should flex impressively.

For those of you who like to see how things work for yourselves you will find the finished character's arm on the resource CD, complete with bone structure, tendon settings and muscular bulges. The filename is LeftArm.scn. Click here to download

Adding and Removing Vertices to a Muscle
You now know that the Attach Skin to Skeleton tool automatically assigns vertices to bones to make the muscles of your characters. However, there is no guarantee that the vertices assigned will work with your character.

You can use the Muscle Properties panel to add or remove vertices using either the Point, Lasso, or Rectangle selection tools. These work identically as the standard Lasso and Rectangle selection tools. To add vertices to the selected muscle, use either of the Point, Lasso, or Rectangle selection tools, click the sphere with the plus sign and highlight the desired vertices. To remove vertices from a selected muscle, use either the Point, Lasso, or Rectangle selection tools and click the sphere with the minus sign. The vertices removed from the

group will be automatically reassigned to the nearest adjoining tendon.

When you're done selecting vertices or wish to select another bone disable the selection tool.

In Summary
Well we created a skeleton, edited its joints, muscles, and tendons, and managed to flex a little muscle. In the next tutorial "Character Animation" we will look at what's involved in animating a character with bones, the things you should consider before getting started, and how to use saved skeletal animations on other characters you create.

Frankly, I think Caligari has given us a wonderfully powerful tool set for posing our characters. Now it's time to turn these poses into animations.