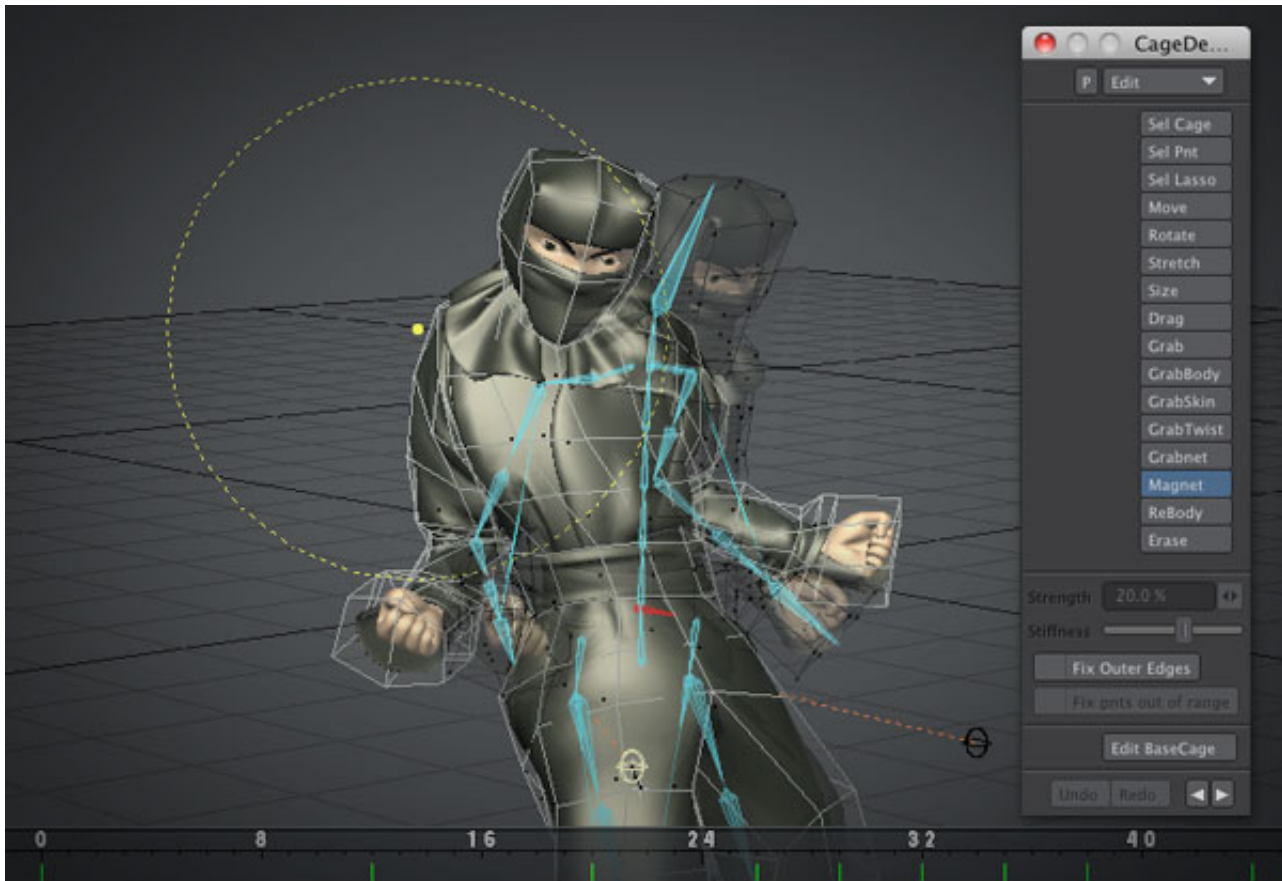## What is Cage Deformer

Cage Deformer is an intuitive animation tool that allows you to freely edit the mesh deformations of your object by wrapping with low-resolution geometry called Cage. The object is deformed along with the cage when you edit the cage. With cage editing tool, you can easily and dynamically edit the cage by grabbing, stretching, rotating, twisting, and distorting. This deformer is very useful for various purposes, such as secondarily correcting bone deformations, adding secondary actions, character animations without any bones, and more.

Plug-ins

This tool consists of the following four plugins:

3PS_CageDeformer (Custom Object)
creates a cage in a scene. Because it is automatically added into a scene by "**CageDeform Add**" command, you don't have to use the Add Custom Object pop-up menu on the Geometry Tab of the Object Properties Panel to apply this custom object plugin to an item.

3PS_CageDeformer (Displacement)
deforms the object under the influence of the cages in the same group by referring to the cages.

3PS_CageDeformer_Tool (Layout Tool)

opens the Cage Deform Tool panel, which allows you to edit the existing cages in the current scene.

3PS_CageDeformer_Add (Layout Command)

adds a new cage into the current scene.

Controls

3PS_CageDeformer_Tool (Layout Tool)

Properties button P - opens the Options panel for the currently selected cage.

Tool Menu - Editing modes are as follows:

> **Sel Cage** - selects or deselects the cages that you want to edit. You can select or deselect the cages by left-clicking and also add more cages to the existing selection by right-clicking. In this mode, you can also cancel your cage selection by clicking in the blank space on this tool panel.
>
> **Sel Point** - selects or deselects the points of the selected cages. You can select or deselect the points by left-clicking and also add more points to the existing selection by right-clicking.
>
> **Sel Lasso** - lasso-selects or lasso-deselects the points of the selected cages.
>
> When no points are selected, every point of the selected cages is considered selected and is affected by editing. If points are selected, only the selected points will be affected by editing. You can also cancel your point selection by clicking in the blank space on this tool panel.
>
> **Move** - moves the whole or selected points of the selected cages.
>
> **Rotate** - rotates the whole or selected parts of the selected cages. The center of the effect is the initial point of dragging.
>
> **Stretch** - stretches the whole or selected parts of the selected cages. The center of the effect is the initial point of dragging.
>
> **Size** - scales the whole or selected parts of the selected cages.
>
> **Drag** - moves a point of the selected cage.
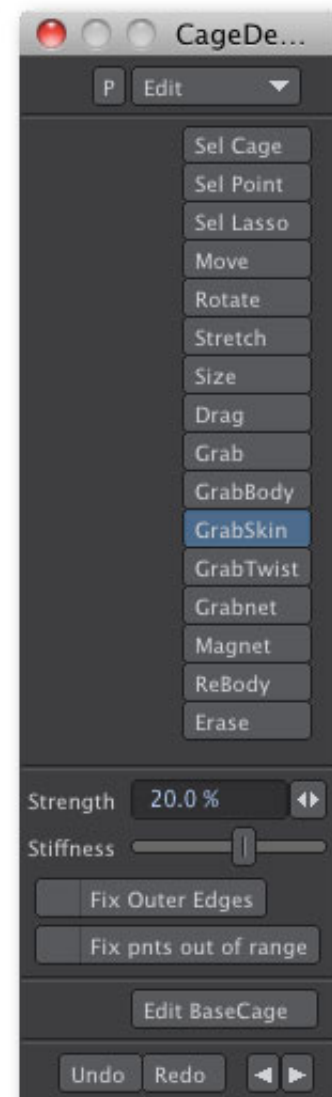
Grab - grabs and moves the surface of the selected cage you clicked on. The center of the effect is the initial point of dragging on the surface. Points within the brush's influence area will be affected.

GrabBody - grabs and moves the surface of the selected cage you clicked on, in a similar way to **Grab**. The only difference is that this mode will try to maintain the volume of the cage, and its retention rate is determined by the **Stiffness** value.

GrabSkin - grabs and moves the surface of the selected cage you clicked on, in a similar way to **Grab**. The only difference is that this mode will try to maintain the surface area of the cage, and its retention rate is determined by the **Stiffness** value.

GrabTwist - grabs and twists the surface of the selected cage you clicked on. In addition, this mode will try to maintain the volume of the cage in the same way as **GrabBody**.

Grabnet - grabs and moves the surface of the selected cages. **Grabnet** is similar to **Grab**, except that all of the selected cages will be affected.

Magnet - smoothly moves points within the brush's influence area in screen space. The center of the effect is the initial point of dragging.

Rebody - corrects the excessive distortion of the surface of the cage. The intensity of the effect is determined by the **Strength** value.

Erase - reduces the displacement amount of each point within the brush's influence area. The intensity of the effect is determined by the **Strength** value.

In **Grab**, **GrabBody**, **GrabSkin**, **GrabTwist**, **Grabnet**, **Magnet**, **Rebody**, and **Erase** modes, you can graphically adjust the brush size by right-clicking and dragging out a circle.

Strength - determines the intensity of the effect. Larger values of **Strength** cause the displacement amount of each point to reach the final result of the effect more quickly.

Stiffness - causes the cage to roughly maintain its own volume or surface area in **GrabBody**, **GrabSkin**, and **GrabTwist** modes. The more the slider is moved to the right, the stiffer the cage is. In other words, it will try to maintain the volume or surface area of the cage much more strongly. However, too stiff cages may be broken when you bend them. In contrast, the more the slider is moved to the left, it allows much more stretch of the cage.

Fix Outer Edges - If checked, the points of open edges (one unshared by multiple polygons) will be considered not selected, and those points will not be affected at all by editing.

Fix pnts out of range - If checked, the points out of the brush's influence area will be considered not selected, and they are not affected at all, that is, they are fixed at the current positions while you are clicking and dragging the mouse.

Edit BaseCage - Checking this option enters base shape editing mode for the currently selected cages. The base (initial) shape of the cage is like bones that are rested. If you want to change it directly in Layout, check this and edit cages.

Undo/Redo - can undo and redo almost all of the changes you made to your cages. This tool has its own undo/redo mechanism in Layout. The undo/redo stack will be retained during having the tool panel open as long as there is enough free space in RAM, and it will be cleared when the tool closes.

Left/Right Arrow Buttons ◀ ▶ - Clicking on the left arrow button will jump to the previous keyframe in the timeline for the currently selected cages, and clicking on the right arrow button will jump to the next keyframe.

Edit Drop Down Menu [Edit ▼] - The commands in this menu are as follows:

> **Set Zero-Key** - creates a keyframe that has no displacement value at the current time.
>
> **Create Key** - creates an interpolated keyframe at the current time.
>
> **Delete Key** - removes existing keyframes. This will remove a keyframe if one exists at the current time. If the selected (highlighted) time range exists in the timeline, all of the keyframes within the time range will be removed. In other cases, all the keyframes of the selected cages will be removed.
>
> -
>
> **Open Falloff Panel** - opens LightWave-style falloff setting panel. Here you can change the falloff setting for the influence area of the brush.
>
> -
>
> **Display: Unseen** - The Display mode of every cage in the current scene is changed to **Unseen**.
>
> **Display: Solid** - The Display mode of every cage in the current scene is changed to **Solid**.
>
> **Display: X-Ray** - The Display mode of every cage in the current scene is changed to **X-Ray**.


Independent Timeline

This tool has its own independent timeline. When you open this tool by clicking on the **CageDeform Tool** button, the timeline appears at the bottom of the viewport window, which allows you to edit keyframes for the current cages in various ways, such as shifting keyframes by left-clicking, copying keyframes by right-clicking, removing keyframes, switching between linear and smooth interpolation settings, and quickly jumping to the previous or next key.

You can scroll the timeline by left-clicking and dragging at the top of the timeline.

A key can be moved by clicking and dragging the key itself directly in the timeline.
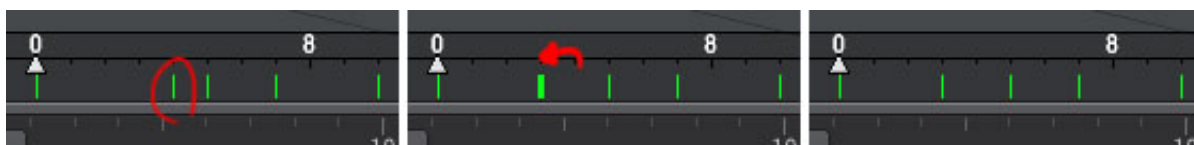
You can select (highlight) a desired time range by right-clicking and dragging at the top of the timeline. If keys are highlighted, all of the keys within the highlighted time range can be shifted, removed, and copied together by clicking and dragging any one of them.
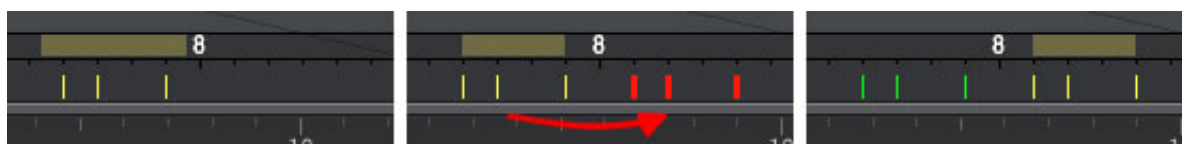
Dragging and dropping the keys out of the timeline will remove the keys themselves. There is no problem even if you remove necessary keyframes by mistake. You don't need to worry about making mistakes because you can also undo the changes made in the timeline by clicking on the **Undo** button.
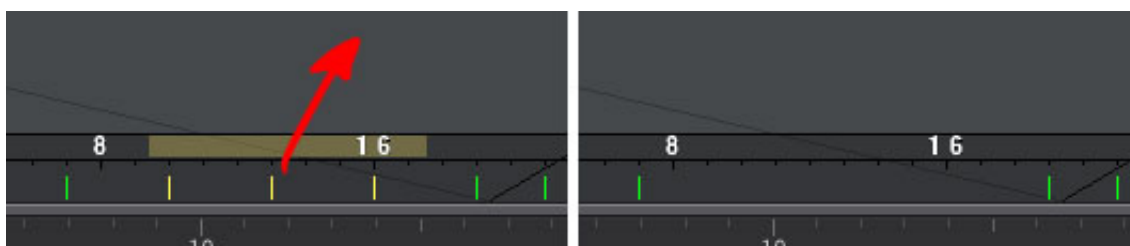
There is the **L** button at the right of the timeline. This button allows you to switch between the types of interpolation of the keyframe at the current time. If On, the shape motion of the cage will be interpolated linearly between the keyframes. If Off, smoothly. Off by default. The left and right arrow buttons have the same functions as the tool panel's.

3PS_CageDeformer (Custom Object)

Display - has the following three visibility options:

Unseen - makes the cage invisible.
Solid - The cage is drawn the same way as the solid object. If the cage is placed behind or inside an object, it will be hidden behind the polygons of the object. If it becomes a problem for you, try switching this to **X-Ray**.
X-Ray - The cage is drawn in front of all the objects existing in the scene. The whole cage can always be seen through objects.

Selected Color - The cage is colored with this color when selected in cage editing mode or when the **CageDeform Tool** is not open.

Unselected Color - The cage is colored with this color when unselected in cage editing mode.

Opacity - specifies the cage's surface opacity.

Group Name - The cage is grouped by this name. To deform your object with the cage, the cage deformer applied to the object must be given the same group name as the cage.

Mode - chooses how the cage affects each point of the object, from the following two options:

> **Skin** - Each point of the object will only be affected by the closest surface point of the cage.

> **Volume** - Each point of the object will be affected by the whole cage.

Falloff Type - sets the falloff strength of influence of the cage. The smaller the number, the softer the cage deformation will be. The larger the number, the harder the cage deformation will be.

Limited Range - If checked, the influence area is limited by distance.

Parallel Distance - specifies the parallel distance between the surface of the cage and the boundary of the influence area.

Perpendicular Distance - specifies the perpendicular distance between the surface of the cage and the boundary of the influence area.
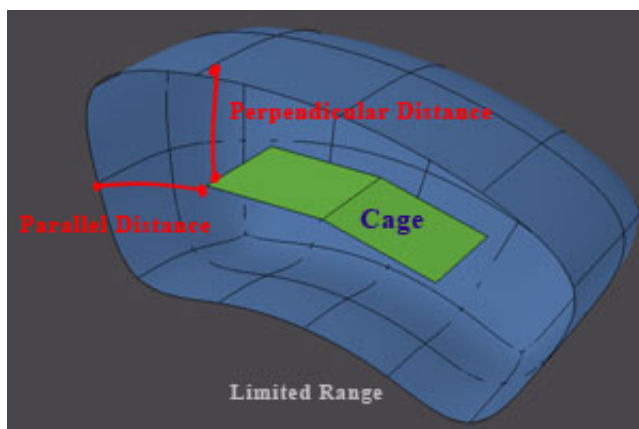
Weight Map - If needed, you can also specify a weight map, which determines how much each point of objects will be affected by the cage. If points are assigned a weight of zero, those points will not be affected at all by the cage. If a weight of 100 percent, they will be affected, completely 100 percent.

Reference Object - If a Reference Object is assigned (usually the original object required to create a cage, which will be automatically chosen as the **Reference Object**), the shape of the cage will always be taken from the deformed shape of the Reference Object at every frame.

As - chooses how the shape of the Reference Object is used, from the following three options:

> **(disabled)** - not used. It is suitable for character animations without any bones.

> **Base** - uses the current shape of the Reference Object as the base (not deformed) shape of the cage. It is suitable for correcting deformations and adding secondary actions.

> **Deformed** - uses the current shape of the Reference Object as the deformed shape of the cage. This option allows you to animate the object with the cage deformed by bones.

Rest Shape at Frame 0 - If On, the shapes of the object and cage at frame 0 (the time objects and cages are rested) in object space will be used as Rest Shapes. Rest Shape is very similar to Rest Positions of bones. The distance between each point of the object and the closest surface point of the cage determines how much effect it has. If Off, the current base shape of the cage in world space will be always used as Rest Shape. It's similar to allowing rest positions of bones to be varied over time.

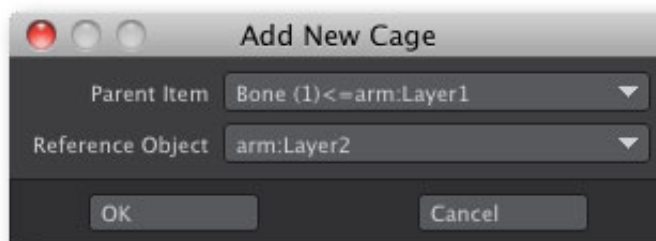## 3PS_CageDeformer (Displacement)
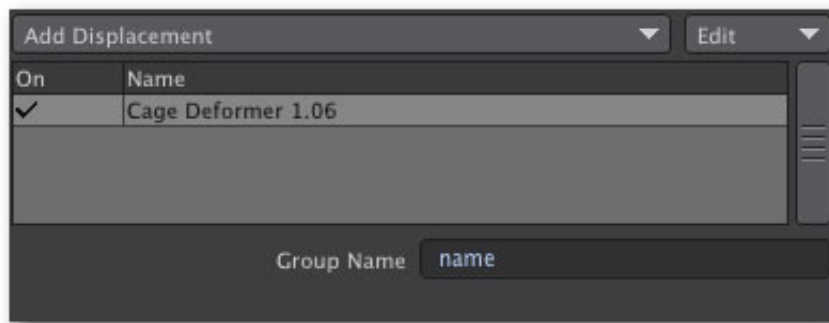
Group Name - The cage deformer (3PS_CageDeformer Displacement plugin) refers to the cage items (3PS_CageDeformer Custom Object plugins) given the same **Group Name** as this to deform the object.

3PS_CageDeformer_Add (Layout Command)

Parent Item - specifies which item the newly created cage is going to be parented to. When this command panel open, the currently selected item in your scene will be automatically chosen as the **Parent Item**.

Reference Object - specifies the original polygon mesh object required to create a new cage.

The **Reference Object** must consist of 2-point polygons (chains), 3-point polygons (triangles), and/or 4-point polygons (quads).

# Example: Secondarily Correcting Bone Deformations with Cages

In Layout, we've loaded the "Arm.lws" file found in the content.
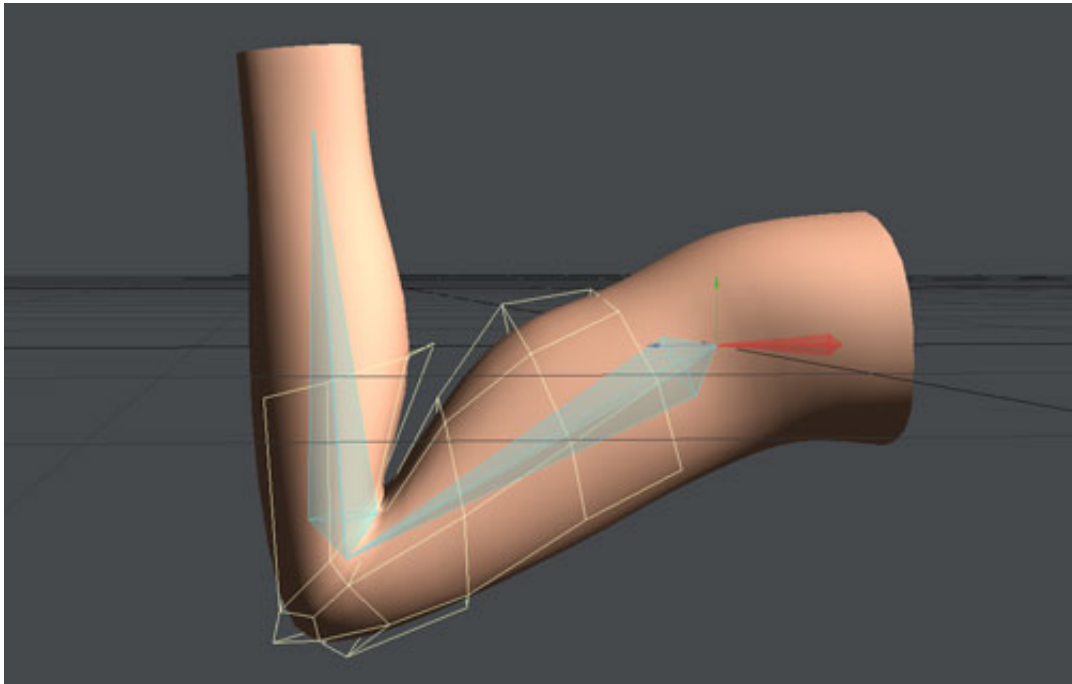

We've got the arm object (Arm:Layer1) that has three bones, and the reference object (Arm:Layer2) for creating a cage. With the Arm:Layer2 object selected, we've clicked on the **Bones** button to switch to the Bone Edit mode, and we've clicked on the **Properties** button to open the Bone Properties Panel, then we've made sure the **Arm:Layer1** object is chosen from the **Use Bones From Object** pop-up menu. Thus, in this scene, the reference object will be deformed by referring to the bones of the arm object.
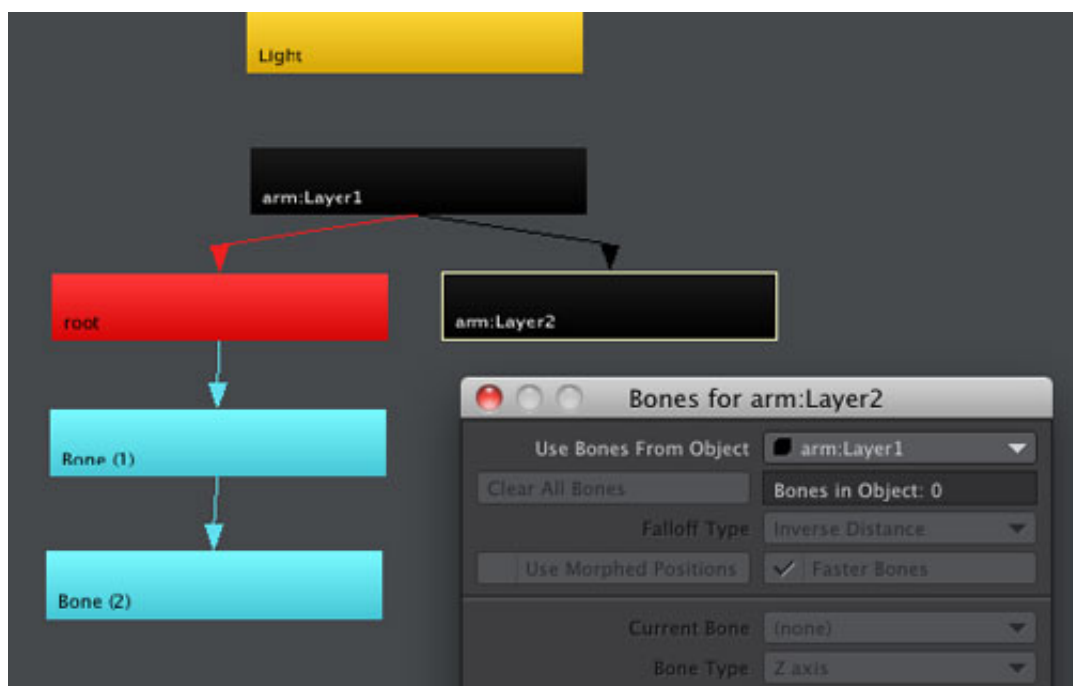
We've moved the timeline slider to frame 0 because the setup for Cage Deformer requires that the object is completely non-deformed, for the same reason as the bone setup. To create a cage to be parented to the Bone(1), we'll select the Bone(1) and use **CageDeform Add** command, and then we'll choose **Arm:Layer2** from the **Reference Object** pop-up and click **OK**.
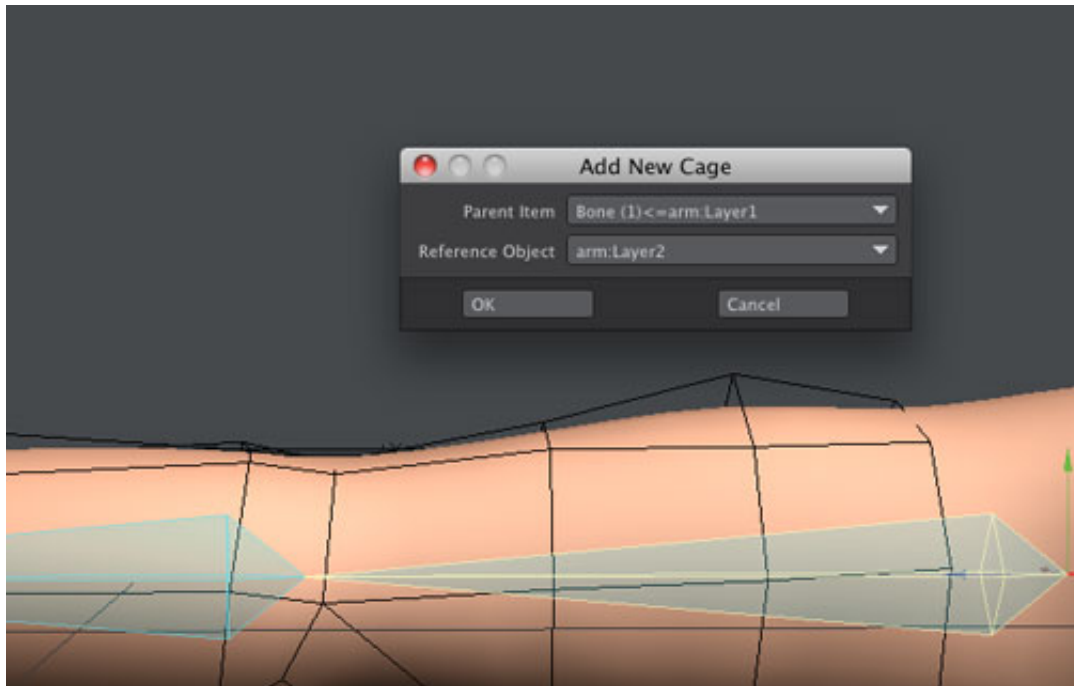

The new cage has been added, and its Options panel has opened. We'll accept the **Group Name** of "**name**" by default, and in this case, we'll use the **Limited Range** option because the cage is limited to a part of the object. Set **Parallel Distance** to **40 mm** and **Perpendicular Distance** to **40 mm**. the **Reference Object** has already been set to "**Arm:Layer2**". Choose **As > Base** to use the reference object deformed by bones as the base shape of the cage. Check the **Rest Shape at Frame 0** toggle to use the shapes of the object and cage at frame 0 (the time objects and cages are rested) in object space as Rest Shapes.
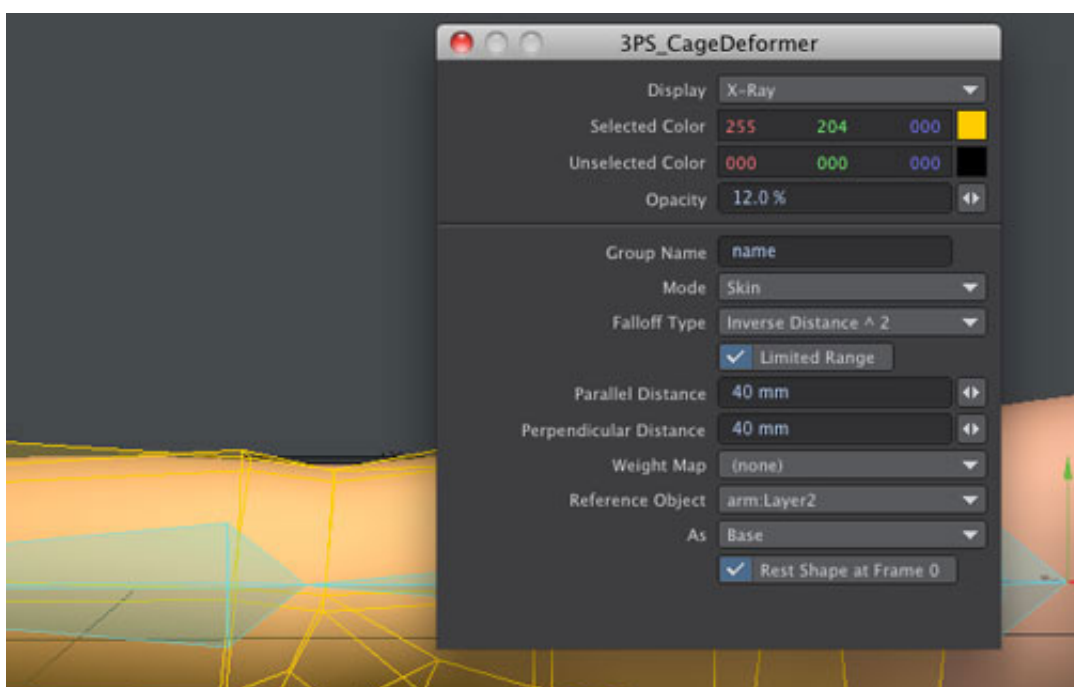
To apply a cage deformer plugin to the arm object, we've opened the Object Properties panel and chosen "**3PS_CageDeformer**" from the Add Displacement pop-up menu on the Deform Tab. Basically, its **Group Name** text field needs to be typed the same group name as the cage to tie the deformer to the cage, but we've accepted the default group name of "**name**" without changing it because they both have already become the same. We're now done with our cage setup.
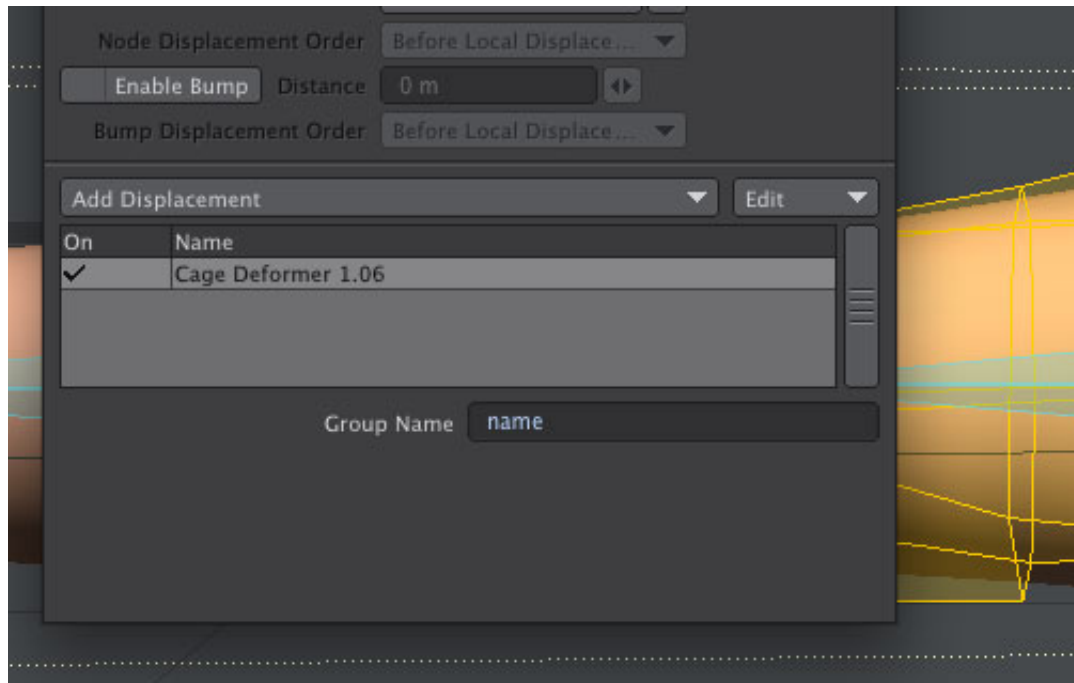

We've chosen **Last** from the Subdivision Order pop-up menu on the Geometry Tab because the arm object is a SubPatch object.
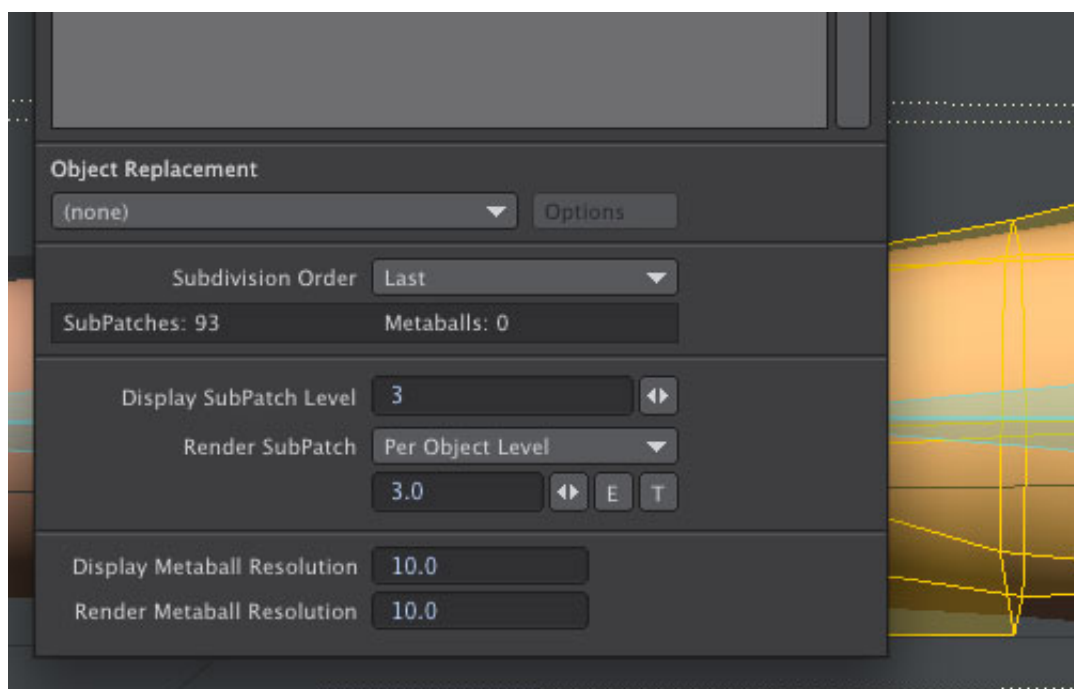
We've made sure we are currently in Object Edit mode because this tool can only open in Object Edit mode. Then we've entered cage editing mode by clicking on the **CageDeform Tool** button in the Toolbar menu. If the internal list of objects have some problem, it will be automatically reordered when this tool opens. The reference object must be before the cage, and the object that is deformed by cages must be after the cages.
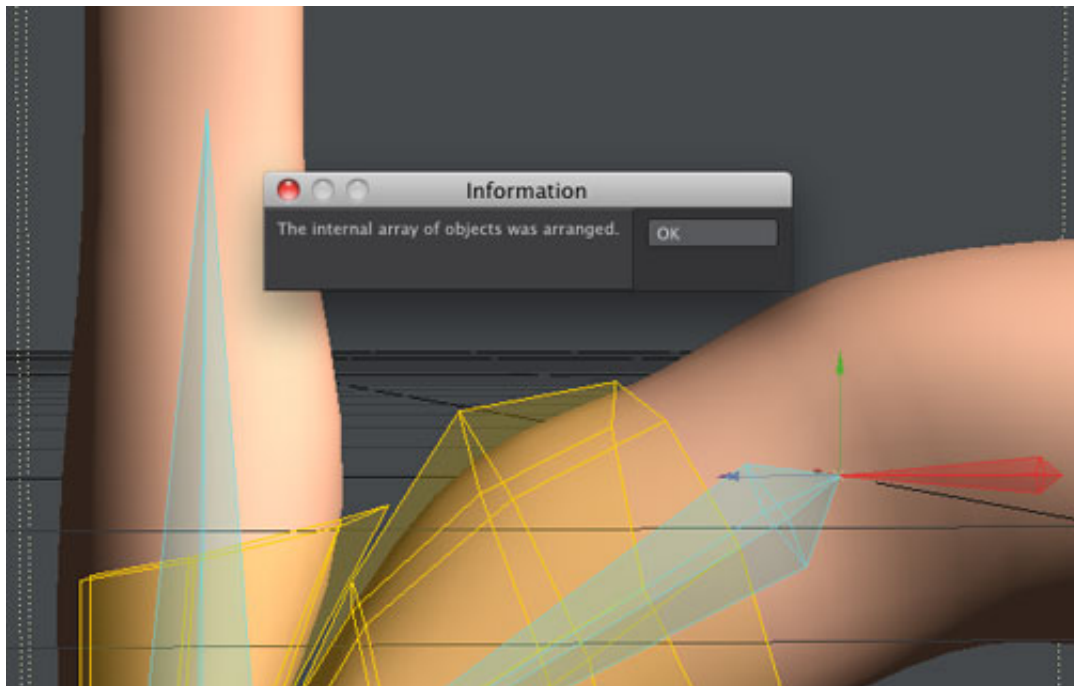
We've moved the timeline slider to play the scene, but the bended arm looks bad due to rough bone deformations. To secondarily correct deformations with the cage, first, we'll choose **Sel Cage** on the tool panel and click the cage to make it editable.
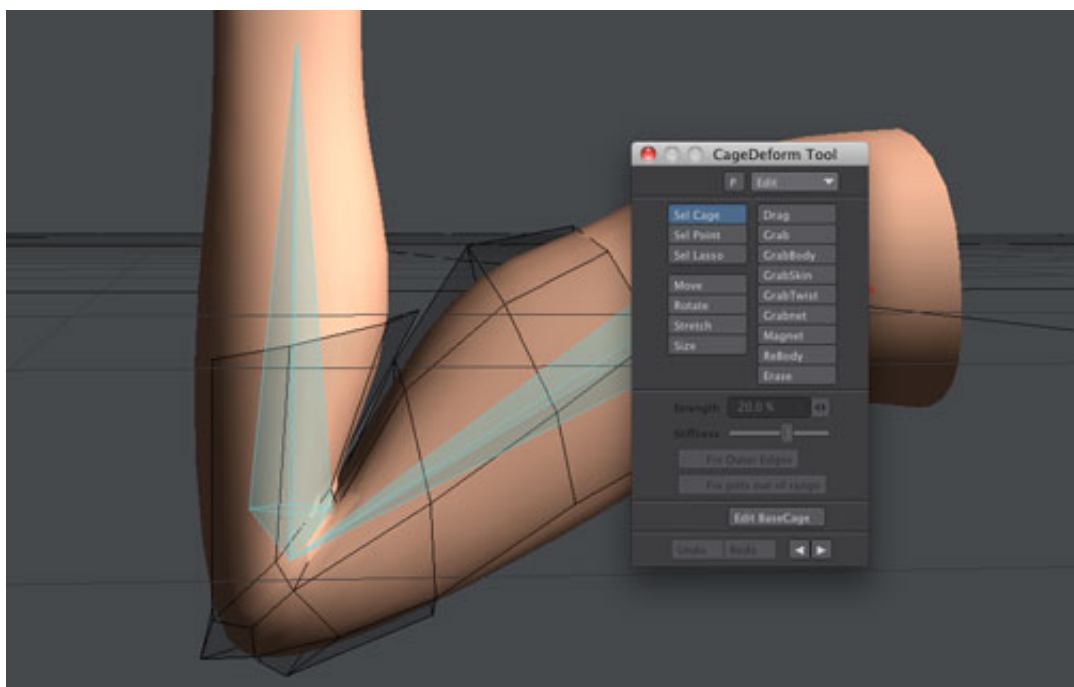
Then, we've chosen **Magnet** on the tool panel and adjusted the brush size by right-clicking, and we've corrected deformations by left-clicking. When we get the desired result, finally, we'll tap the spacebar or close the tool panel to quit CageDeform Tool. Using other tools or commands with the CageDeform Tool panel open is not recommended.
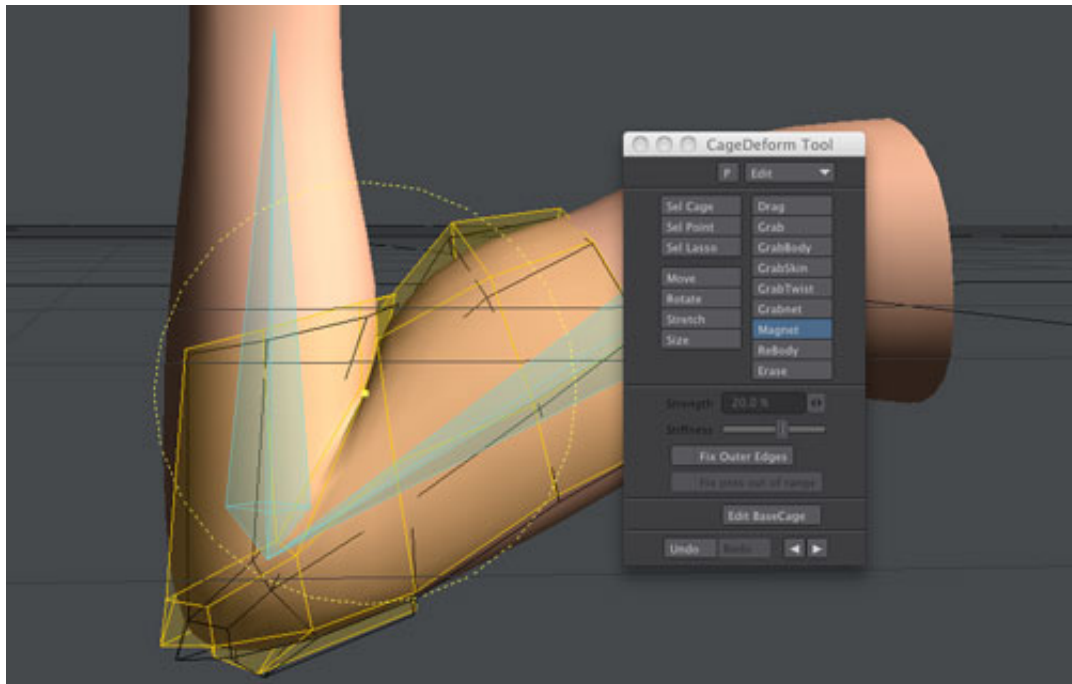

Example: Bone Deformations via Cages

We've loaded the "Arm2.lws" file. In this scene, the reference object (Arm2:Layer2) has three bones, and the arm object (Arm2:Layer1) has no bones. We will be explaining the processing order for deformations here. First, the reference object will be deformed by bones, and then the Deformed shape of the cage will be taken from the deformed shape of the reference object. Finally, the cage deformer will deform the arm object by referring to the base and deformed shapes of the cage.
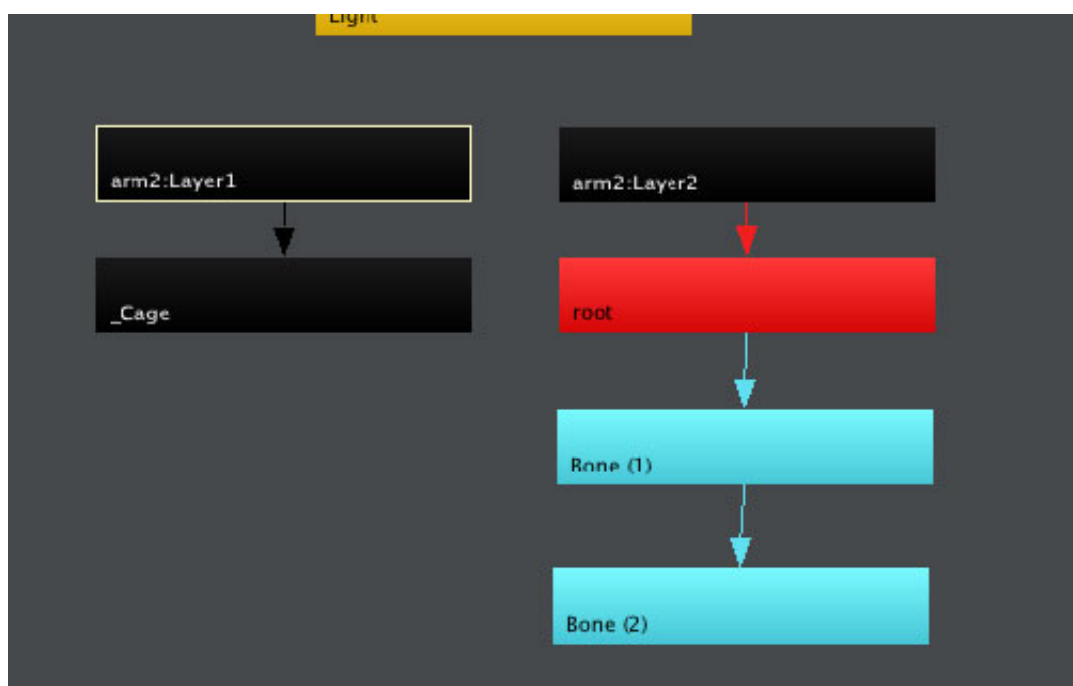
Let's explore the scene and find differences from the previous scene. We've selected the cage item named "_Cage" and opened the Object Properties panel. Then, we've opened the Options panel for the Cage Deformer Custom Object plugin applied to the cage item on the Geometry Tab. According to that, the **Limited Range** option is disabled, and **Deformed** is chosen from the As pop-up menu so that the deformed shape of the cage will always be taken from the deformed shape of the reference object.
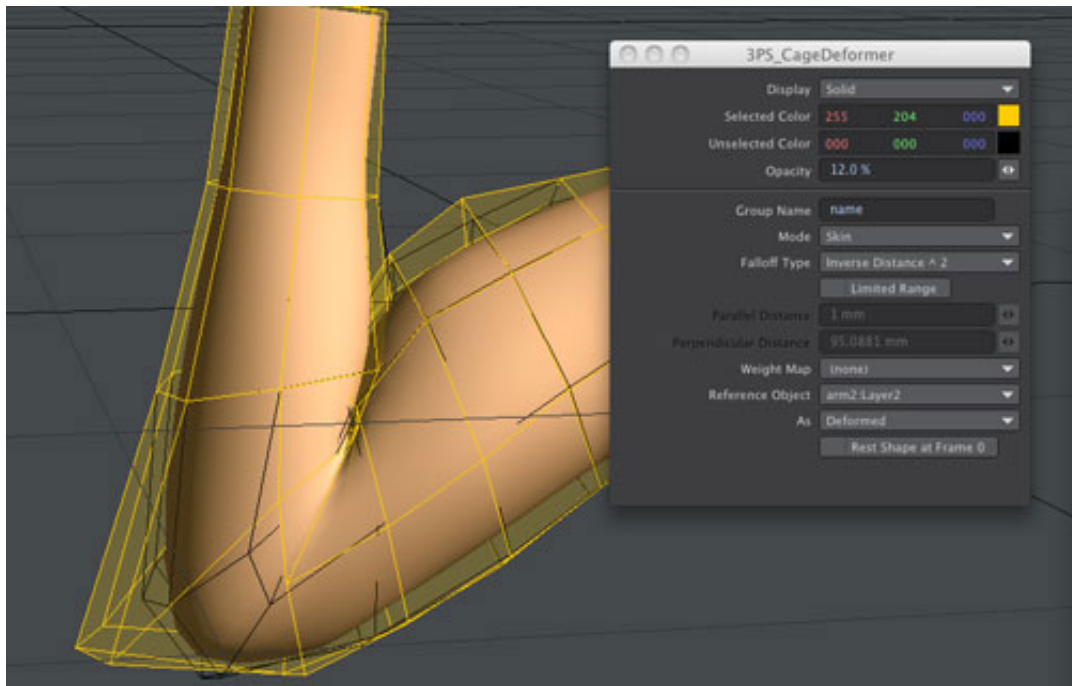
Example: Full-body Cages

We've loaded the "DeskLamp.lws" file. In this scene, the whole of the desk lamp object that has no bones is completely wrapped in just one cage, which is the simplest cage setup. We can animate it without any bones. We'll open the tool panel by clicking on the **CageDeform Tool** button, and we'll choose the **GrabBody** mode for deforming the cage while maintaining its volume. Now, let's give life to the character by bending and stretching the cage.