Advanced Character Modeling Using Polygons and Subdivision Surfaces

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Subdivision modeling *has become the standard for character modeling in most video and film environments. Maya has implemented a powerful and user-friendly way to use subdivision surfaces. The purpose of this chapter is to show you a proven method to create a complex shape—a character's face—using subdivision surfaces.*

The human face could be the most easily recognizable, familiar, and expressive 3D shape known to humankind. Anyone can easily spot the subtle nuances and details, but this shape is notoriously difficult for an artist to get just right. In this chapter, we'll create a human face from a conceptual sketch, an exercise that will give you the ability and tools to tackle any model that uses organic forms and shapes.

We'll employ the concepts and artwork of Krishnamurti Costa, a prominent and talented 3D artist. We'll document his techniques and processes in detail, explaining every step he uses to create his artwork.

Modeling Concepts

Certain modeling practices and guidelines are universal concepts that can be applied to any model. The way a model deforms, animates, and renders depends on how the model is built. The flow of the geometry requires planning, and the planning of the model begins before the first curve is drawn.

Modelers and studios use different processes to create polygonal models. Any given process will create different results. Many modeling tutorials suggest an approach in which the modeler uses primitives to start a model and fills in the detail later. Some studios use 3D scans or hand-digitized 3D data to begin modeling.

The approach in this tutorial uses carefully placed rows of polygons to create an easy-to-edit polygonal cage. This technique is called poly-by-poly modeling. The polygonal cage is the basis for the subdivision model. If the geometry flows naturally along the surface of the model, texturing, lighting, rigging, and animation are much easier later in the production process.

Before modeling takes place, it is important to understand the model that you will be creating. How will it move? What kind of detail will be required? Where is the detail going to be? How will it be textured? What kind of lighting will be applied to it?

The production requirements for a model can be considerable and can change during the time the model is being created and used in production. It can be impossible to know exactly what will be required of the model before it is created, but a good modeler attempts to make educated assumptions about these requirements.

An experienced modeler knows that two things will probably happen when they are given a model to build for a project:

- If they are told that the model will not have to be too detailed, the model will almost certainly appear full screen at some time.
- If the model is detailed to support any amount of close-up scrutiny, the rendering deadlines will require that the model's level of detail be taken down to the absolute lowest levels possible to expedite production.

Luckily, subdivision modeling supports both scenarios. When you carefully plan your model and execute using levels of detail in the subdivision, the model can hold up to careful scrutiny, and the detail can be reduced quickly and easily to render out fast and easy.

Using Conceptual Art: Laying Out the Views in 2D

The character we'll work with in this chapter is stylized, but it has human features to provide a variety of modeling situations that can be explored for this tutorial.

Instead of creating a 3D model from scratch, we'll use artwork to illustrate how a model can be created in a professional environment. Seldom is an artist given a project to work on that they have complete creative control over. When an artist is shown how to model from a piece of artwork, they can easily use that technique in a professional situation in which they will be asked to create models from conceptual art.

The drawings in Figure 9.1 are excellent examples of the level of specifics needed in the artwork to create a detailed subdivision model.

A minimum of two views are necessary to create an accurate 3-dimensional model from 2-dimensional artwork. In these views, called orthographic views, the overall dimensions must line up between the drawings. The overall length, width, and placement of the details such as eyes, nose, and mouth must be aligned between the two drawings, as in Figure 9.2.

Modeling Standards

Modeling standards change from studio to studio. In some cases, for example, it's fine for a subdivision model to have a lot of triangles, and in other cases triangles are strictly forbidden.

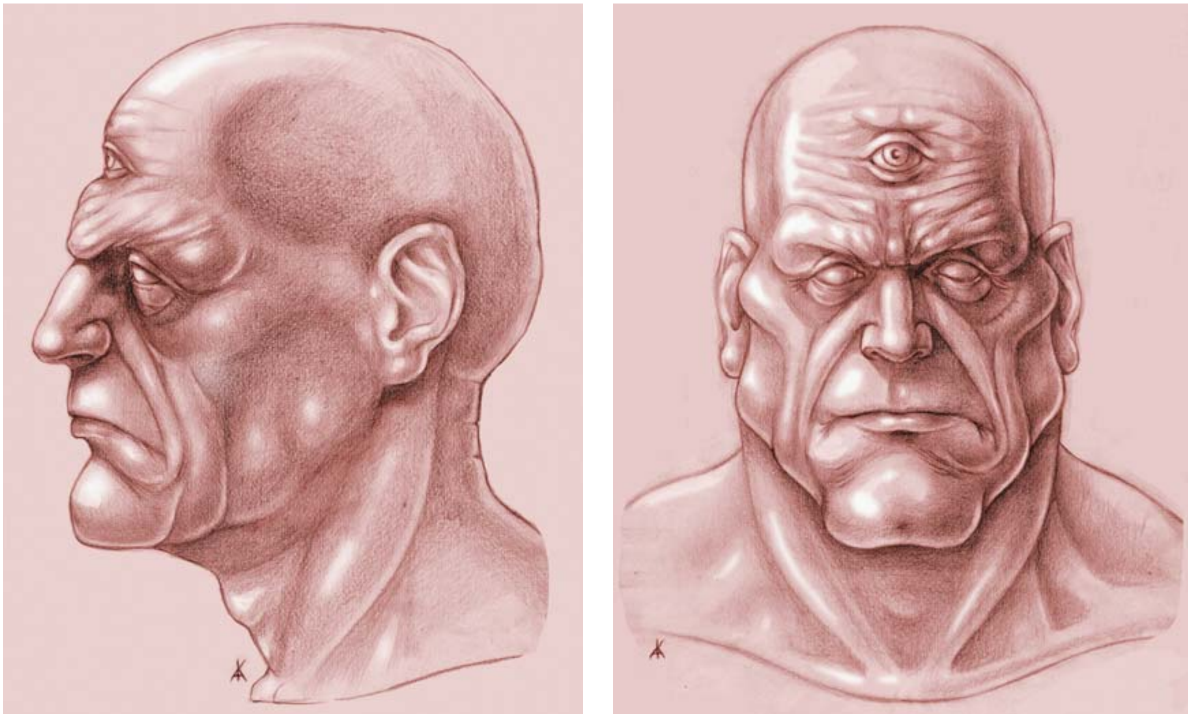


Figure 9.1: Detailed front and side views of a character

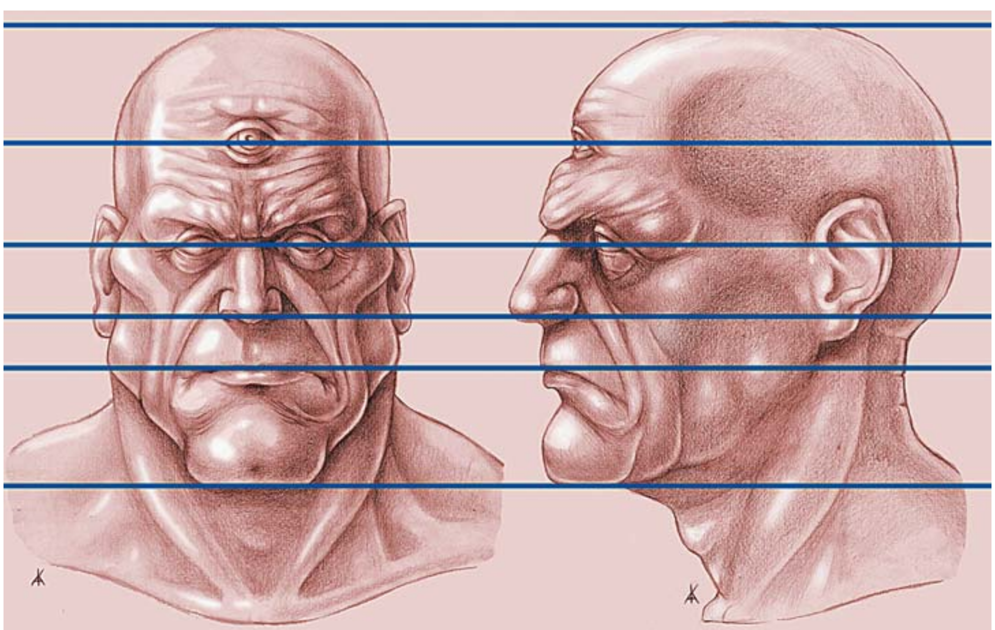


Figure 9.2: Two views aligned

Generally, if it looks good in animation and lighting, you'll be allowed some freedom in the process used to create the model.

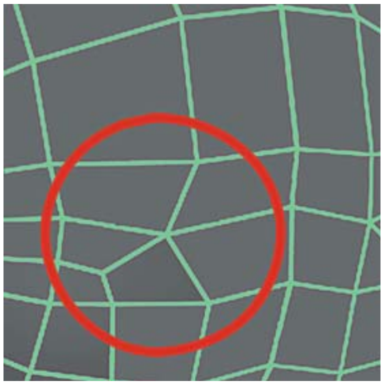


Figure 9.3: A star condition in a polygon layout

Modeling processes have changed over time, and what was considered fine practice a couple of years ago is now not allowed. Two specific cases in point are the use of triangles in a subdivision model and the occurrence of a condition called a "star."

Subdivision models work much better with four-sided polygons than with three-sided polygons. In our exercise, the model has no triangles whatsoever. With careful placement of edges, and by using the tools explained here effectively, it is possible to create high-quality models that have no triangles.

A star is a place where five edges come together in one corner. This condition can cause many problems in animation and lighting. They create irregular flashing and twisting when the object is used in production. The model in Figure 9.3 has been built to the standards specified here and was produced using just four-sided polygons. Stars, on the other hand, are harder to avoid because they're caused by the edge loops crossing. You can control stars and place them where there is little or no deformation. When it is impossible to avoid a five-cornered condition, always avoid putting the star in a place where there will be a great deal of movement.

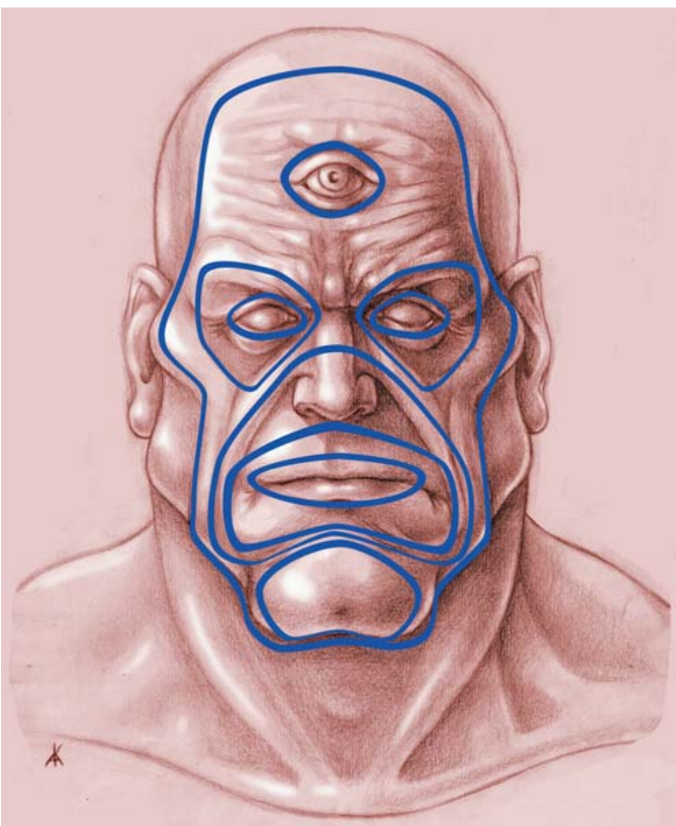


Figure 9.4: Areas of animation

Animation Flow

The first concept to consider when planning the flow of geometry in a model is animation flow. The "flow" of the geometry must support the way the model will move. A model must have geometry that can be moved along the lines that the model will be required to move.

The areas that are required to move in this model are the eyes, mouth, and jaw. The flow of animation in these areas will surround these areas. By outlining the general vicinity surrounding the areas of movement, as shown in Figure 9.4, we can visualize how the geometry will need to flow along the model.

This geometry flow is simple to understand. Geometry must flow radially away from areas of movement (see Figure 9.5). The careful arrangement of radial polygon rows placed along the paths of motion make the model easy to rig and animate. Rows of polygons that surround the animation areas

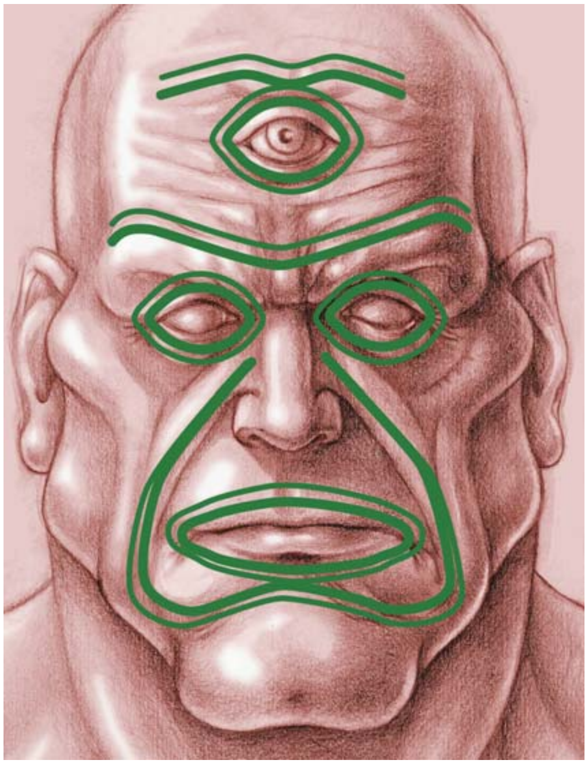


Figure 9.5: An animation flow diagram

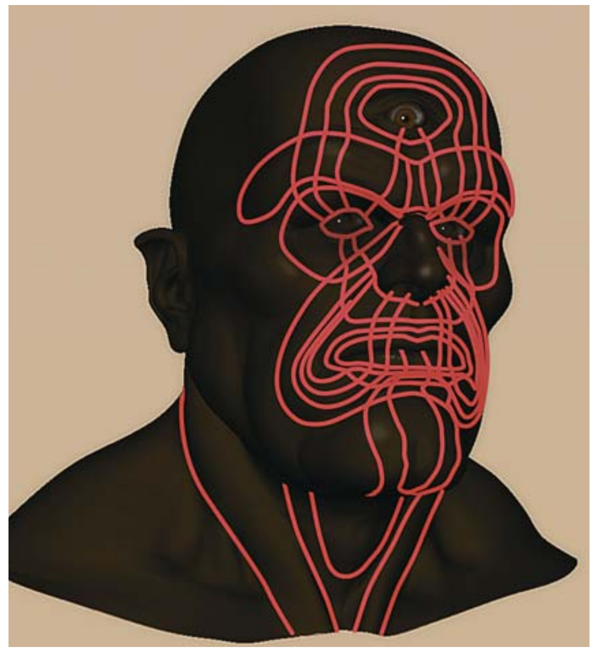


Figure 9.6: Muscle edge loops

create uniform movement in the model, define the anatomic forms better, and allow the model to render properly as well.

Edge Loops

A more complex idea that relates to construction is the concept of edge loops. Edge loops are related to animation flow, because they follow the muscle construction in the actual face, and the face naturally moves along the path of these muscles. But the edge loop concept takes the idea of animation flow and expands on it to cover the construction of muscle groups, bone areas, and areas of fat along the surface of the face.

Muscle edge loops are placed around areas of the face that will move: the eyelids, the lips, the brow, and the jawline. Model muscle areas carefully to avoid awkward intersections and triangles. These areas require the closest scrutiny when animating and present the most problems if not modeled correctly.

When defining the edge loops of the muscles, try to integrate the muscles by defining not only lines that are parallel to the areas of movement, but also lines perpendicular to the movement where muscles will connect. In Figure 9.6, notice how the lines flow around the lips, but lines flow through the lips as well. These lines allow the flow of the geometry of the lips to align with the flow of the geometry of the cheek and jaw muscles.

Fat edge loops, like those in Figure 9.7, define the areas of the face where movement takes place, but it is passive movement that is not driven by a direct force. This movement is caused by the muscles. You must model fat areas as carefully as muscle areas because they will move almost the same amount. Fat areas do not really have to interact with other fat areas. Fat areas exist as small islands of passive flesh that allow the muscles to move freely.

Figure 9.7: Fat edge loops

Bone edge loops are the hard areas of the face where the bone comes closest to the surface, as shown in Figure 9.8. These areas do not have much flexibility and will not have much movement within them. For this reason, it is convenient to use these as places where the model can have transition areas such as five-cornered intersections. Because these areas do not move much, some geometric flaws can go unnoticed if constructed carefully.

You use the entire edge-loop layout (see Figure 9.9) to plan the placement of the geometry during construction. Using careful planning and geometry placement, you can build a model that is easy to edit and animate. Even if the model will not be used for animation, a good edge-loop layout can help define the anatomic details of your model, just because bones, fat, and muscle loops are part of the same main volume.

Figure 9.8: Bone edge loops

Figure 9.9: Edge-loop layout

Modeling the Face

Once you have a basic understanding of the flow of the geometry, you can begin the process of building a wire cage. The modeling process is much like any other kind of artistic endeavor. You work on the piece until the work is finished, and throughout the course of the work, many operations take place. You build something, tweak something, and erase something else. These steps build up over time until you have accomplished a number of small things that amount to a big piece of art you are proud of.

The problem with modeling in Maya is that the computer remembers everything you do. You can set history to a small number of steps to mitigate this overhead, but over time it is important to optimize the work flow by performing certain steps during the modeling process.

Save often. Save your file many times over the modeling process to unique and sequential names. These names are usually something like `workFile.0001.mb`, `workFile.0002.mb`, and so on

Delete history often. History slows you down to the point where simple tasks take a long time. Experienced modelers recognize quickly when the history starts to be too much and delete it.

Subdivide the model judiciously. Subdivision is a great way to create high-quality models quickly. The subdivision process itself, however, is computationally expensive. In this exercise, we build the model almost entirely using only polygons until the end, when subdivision modeling is necessary. During construction, view the subdivision model periodically to make sure the model is progressing correctly. In these cases, the model is subdivided to preview the progress, and then the subdivision operation is undone so the clean and light polygon modeling process can continue.

The process for modeling the face consists of placing the image planes in 3D, creating a wire cage that outlines the details of the face, and creating a polygonal cage from which to create the subdivision surfaces.

Laying Out the Image Planes in 3D

Load your images before manipulating the viewports. If there is any camera movement in the viewports before the image plane is imported, choose **View → Default Home** (at the top of each viewport) to reset the view.

Load drawings into the Maya viewports by choosing **View → Image Plane → Import Image** from the viewport menu. Locate the front and side images in the respective front and side viewports, as shown in Figure 9.10. This will create a perspective view in which the images can be seen positioned at 90 degrees to each other. The perspective view is where a lot of the wireframe modeling takes place. To see an example of the modeling windows set up with the image planes, open `subD_modeling01.mb` on the CD.

Now we are ready to begin laying out the model in 3D. To make the modeling process easier, build a rough wire cage using splines that will be the basis for the polygonal modeling process. The polygonal cage will be used to create the final smooth model that will be animated and rendered. The wire cage will be the skeleton for the model.

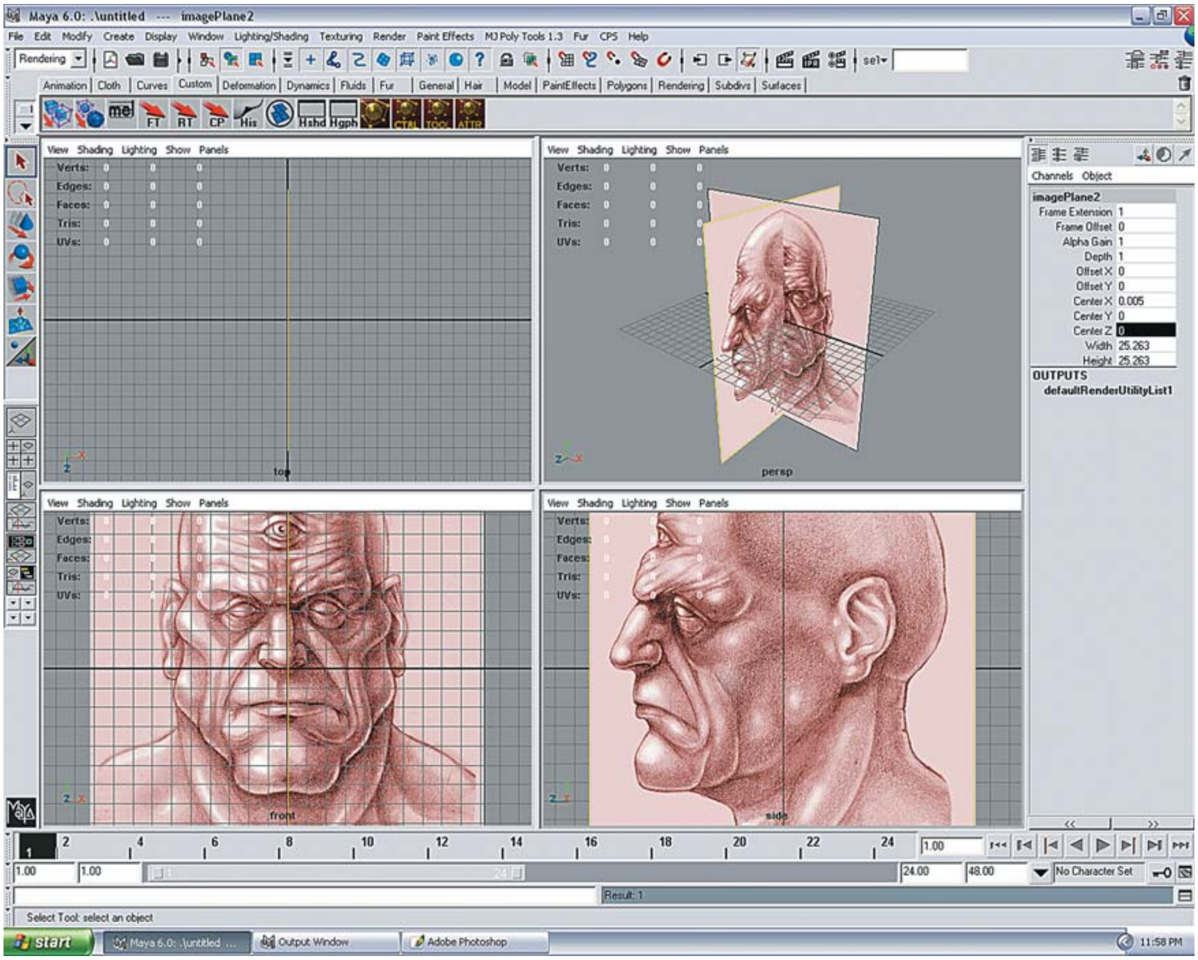


Figure 9.10: Images loaded into viewports

Creating a Wire Cage

The previous section explains in detail how to prepare for modeling a complex organic model. Now that we have done our homework and have a plan, it is time to set our plan in motion. The next steps will create a 3D digital armature for creating the polygonal head.

The wire cage needs to follow the animation flow lines and the edge loops. The wire cage represents your modeling strategy from which all the modeling will take place. For this reason, this modeling phase is one of the most important steps to get right. Once polygonal modeling has started, it is difficult to go back and change your strategy.

Build the wire cage using curves that are easy to control and still give an accurate representation of the form that you are trying to create. Choose **Create → EP Curve Tool ❐**, and then create degree 1 Edit Point NURBS curves with Uniform Knot spacing. These curves are the most similar to polylines (an entity type that is not supported by the Maya modeling software). Since we are building a polygonal cage from the wire cage, it is simpler to use degree 1 curves.

Start by drawing curves in the front view. Begin tracing the details of the drawings using fairly simple curves, as in Figure 9.11. Remember, the more points you use now, the more points you will need to edit later. Capture the outlines around the eyes, cheeks, chin, and the rest of the face as shown. Lay out the curves roughly around the areas of animation so the model can be built along these lines later.

Once the front view is finished, the curves in that view all rest in one place at zero in the Z axis. After you draw the front-view curves, you must edit the curves in the front view to match the side view. Begin, for example, with the curve in the lower eyelid, as shown in Figure 9.12. Translate the curve outward in Z to position the curve correctly. Edit the curve point by point to get the curvature correct along the Z axis.

Continue this process with the rest of the face. You need to edit the curves already drawn before adding details for the side view (see Figure 9.13). Curves such as the bottom of the chin and the brow might need additional information so that they flow

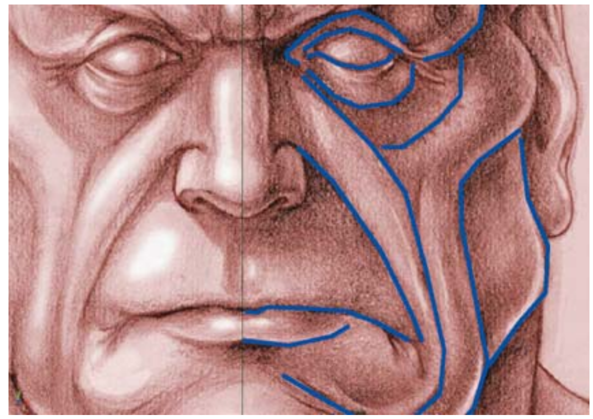


Figure 9.11: EP curves drawn on the face

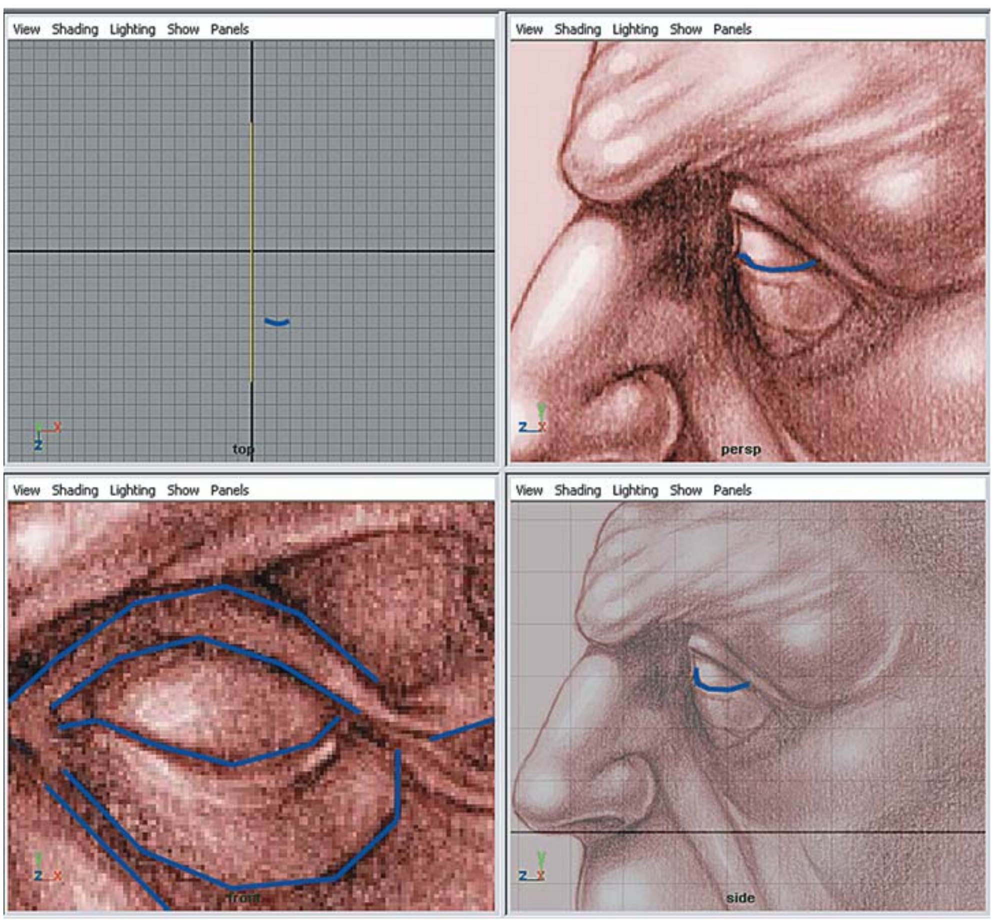
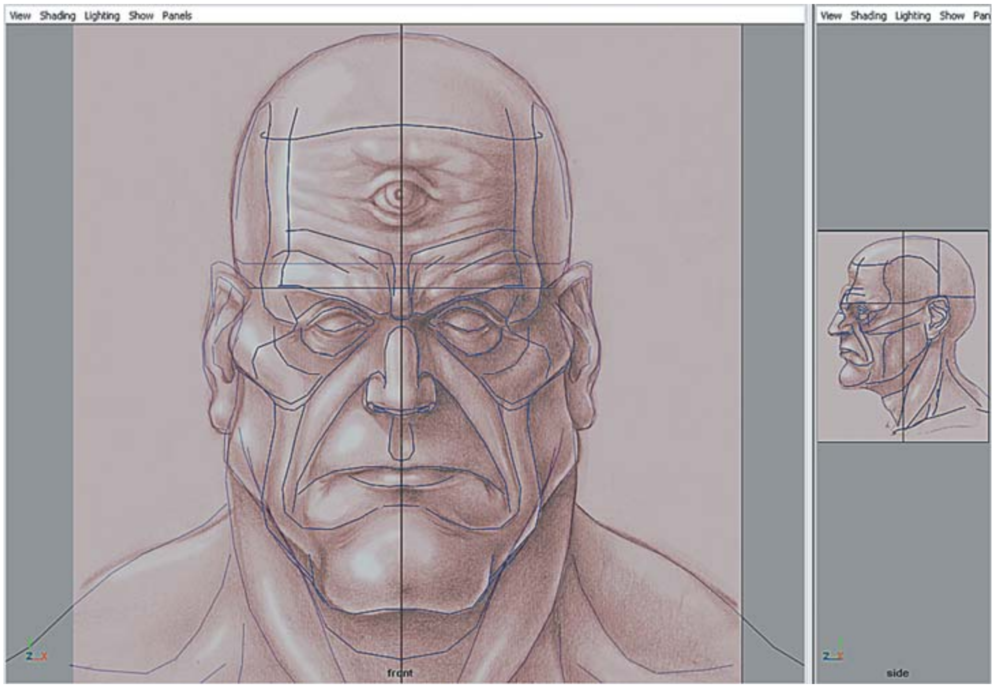


Figure 9.12: The lower eyelid curve edited

Figure 9.13: Front and side view of the wire cage



correctly along the Z axis in the side view (see Figure 9.14). You can do this by adding curves in the side view that extend the front-view curves beyond their original extents and joining the curves later during the modeling process. To see the construction of the wire cage, open `subD_modeling03.mb` on the CD.

Work on the wire cage until it is a clean representation of your concept. This is a critical step in the modeling process. This wire cage will allow you to visualize your design in 3D before you begin creating polygons and subdivision surfaces using easy-to-edit degree 1 curves. You can edit this wire cage later, so do not waste unnecessary time finessing it. This is a strategy, not the final model. If your plan is basically shown in 3D, you can proceed to the next step.

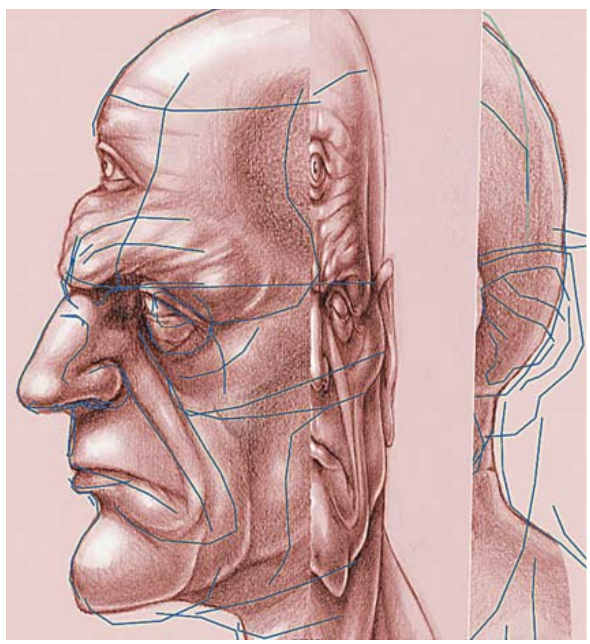


Figure 9.14: Perspective view of the wire cage

A Warning about Orthographic Projections

The process described here uses orthographic projections to create 3D models. This is a fast and accurate way to get 3D form from easily interpreted 2D drawings. This process has been used for years in traditional and digital artwork to make just about any conceivable 3D shape.

But there is a problem with this process. Orthographically created models tend to look boxy when completed. Take precautions so that this does not happen as the model comes together. The edges of the model, the places where the edges of the views come together, sometimes get an unnatural boxlike form; sculpt this out.

A good way to think of this is to picture the creation of a sphere using orthographic views. First, you lay out two really nice circles in the two orthographic views. You then cut out a piece of digital clay to be perfect circles from each of the two views. We're done, right? From the front the sphere looks fine, and from the side the sphere looks fine. But when the model is viewed from the perspective camera, the model has a really ugly outer edge going down the corner. It is up to you to round out the sphere from the basic shape created using the orthographic method.

The same thing can happen during the modeling process of a human face. It is your job to make sure that the corners of the model have beautiful 3D roundness. You can achieve this only by constantly rotating the model in the perspective view, looking at it from every imaginable angle, and trying to get the form as natural as possible.

Unfortunately, Maya has no "make cool" button. You must use your eyes and understand the finished form. There are some tools, however, that can help you along the way, and the section "Creating a Polygonal Cage" explains them.

Creating a Polygonal Cage

Most artists use their favorite tools to create their artwork. The same is true of modelers. You don't have to use all Maya polygonal modeling tools to create a great model. The trick is to get good at the tools you really need and know when to use them.

The next few sections show how specific tools are used at different stages of the modeling process. The tools that are used relate to the process that is taking place. As with all modeling projects, the model starts with simple forms and moves into more complex and refined shapes later.

The tools that are used at these phases of construction reflect the way that the construction goes from simple to complex. In the process of constructing the polygonal head, you'll use many tools, but you'll primarily do the following:

- Choose **Polygons → Create Polygon Tool** and **Polygons → Append to Polygon Tool** to create the entire main form of the head.
- Choose **Edit Polygons → Split Polygon Tool** to cut faces to add more details or change the edge-loop layout of the model.
- Choose **Edit Polygons → Extrude Edge** to extend the rows of polygons to cover large areas of the model quickly. Choose **Edit Polygons → Merge Vertices** to collapse vertices and close holes in the mesh.
- Choose **Edit Polygons → Sculpt Polygons Tool** and **Modify → Transformation Tools → Soft Modification Tool** to create subtle and controlled modifications to the geometry using a "faded deformation."
- Choose **Edit Polygons → Collapse** to reorganize the polygonal layout of the model surface by collapsing different edges into only one.
- Choose **Edit Polygons → Extrude Face** to create interesting areas of detail that maintain excellent geometric layout.

Creating and Appending Polygons

As I mentioned earlier in this chapter, the process we are using is called the poly-by-poly modeling method. This method works well because we are not making discrete patches of polygons from curves, merging them after the fact. The benefits to this process and the process of creating merged patches are as follows:

You need not predetermine the number of points per spline. When making patches, the number of polygons per patch is determined by making sure all curves have a specific number of vertices. Keeping track of this can be tricky and, at the very least, time-consuming. Since you are just making a polygon model that will be subdivided, this step is unnecessary using the poly-by-poly method.

You need not keep track of face normals. When you are making patches, the direction of the face normals depends on the way you create the patch. You need to keep track of the order in which you select your splines when making patches and the direction in which the splines were drawn. If you screw up the direction of the face normals and merge a model created using patches, your model will not subdivide. You will spend a lot of time reversing polygon normals until you get them all lined up.

You need not spend as much time merging faces. Some steps in this process require merging polygonal patches. For the most part, by building the model polygon by polygon, the merging occurs as the model develops.

Using this process, polygonal modeling begins with the creation of a single polygon. Using the edge loop layout, you can place polygons strategically and then duplicate them into rows by choosing **Polygons → Create Polygon Tool** (see Figure 9.15). To draw polygons, use the Snap To Curve function or press the C key while drawing the polygon. The points of the polygon snap to the wire cage that you constructed earlier.

The next step is to append the polygon into a string of polygons by choosing **Polygons → Append to Polygon Tool** (see Figure 9.16). The Append to Polygon tool works much like the Create Polygon tool, but you must first select the polygon that needs to be appended and then select the edges of the new polygon (the one you are building) that are beyond the original polygon (the one that was created using the Create Polygon tool) using the C key to snap the new edges to the wire cage curves that were drawn earlier. The Append to Polygon tool makes polygons that are already merged to the original polygon, and they do not require cleanup.

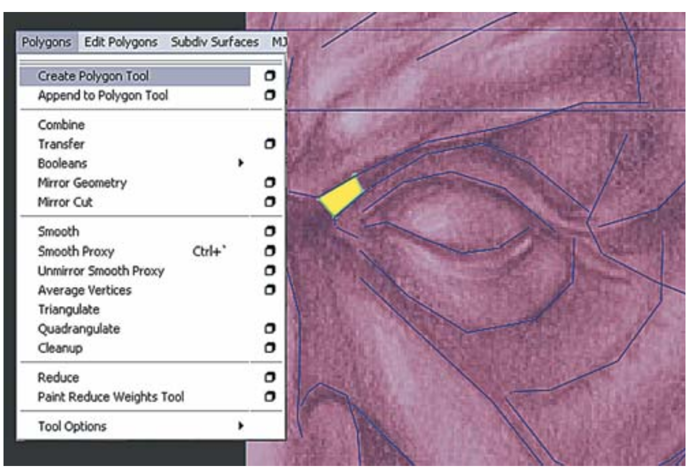


Figure 9.15: The Create Polygon tool

Proceed around the eye, and then press Enter to complete the process. For the next row of polygons, choose the Append to Polygon tool again, but use the lower edge of the polygon to create the next row of polygons. From the sequences of images in Figures 9.17 and 9.18, it is apparent how using the Append to Polygon tool can be a useful way to create a fast network of polygons.

Once there is an adequate number of rows to begin visualizing the shape of the eye

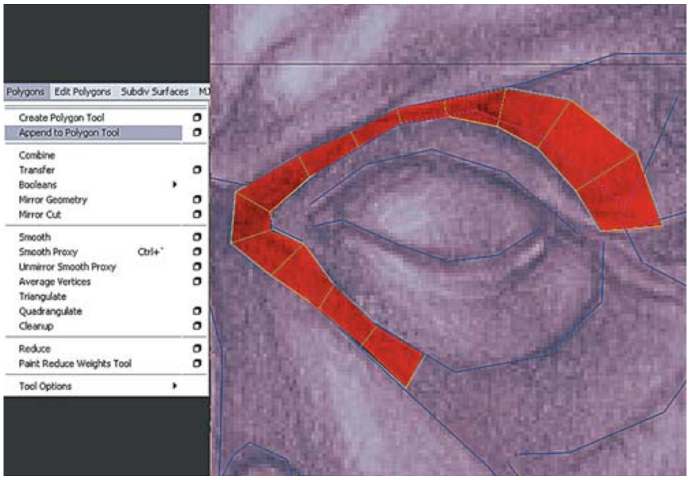


Figure 9.16: The Append to Polygon tool

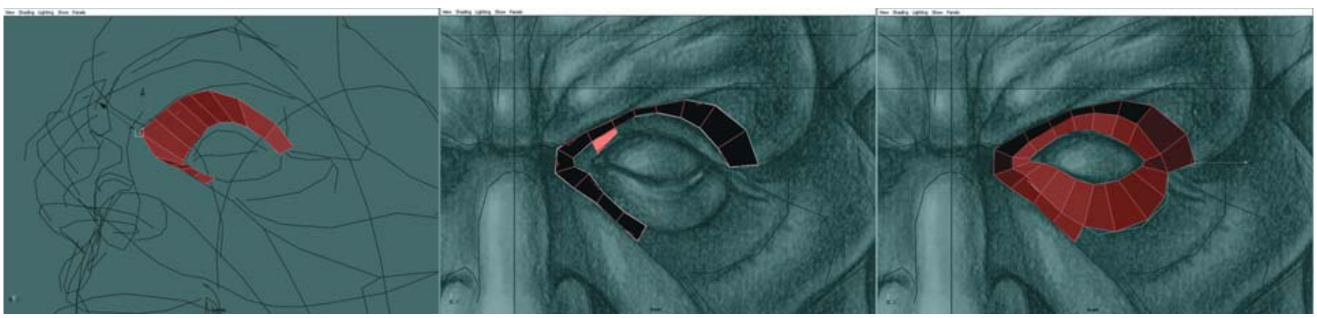


Figure 9.17: Append Polygon, inner rows

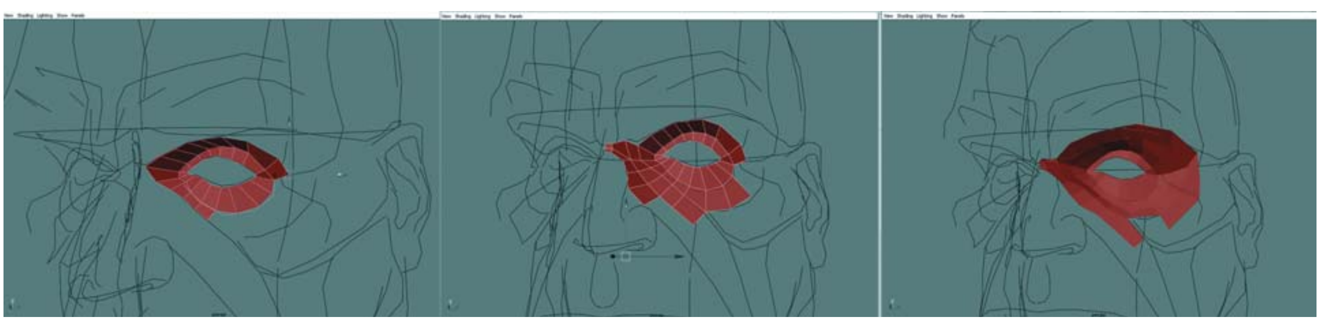


Figure 9.18: Append Polygon, outer rows

and cheek areas, you might need to duplicate the eye area across the X axis. When you do this, it is important to choose **Edit → Duplicate → ❐**; then set **Scale** to –1 in the X axis and set **Geometry Type** to Instance (see Figure 9.19). This will allow the model to update instantly as one side is changed. To see the initial polygonal modeling, and the mirroring across the X axis, open `subD_modeling04.mb` on the CD.

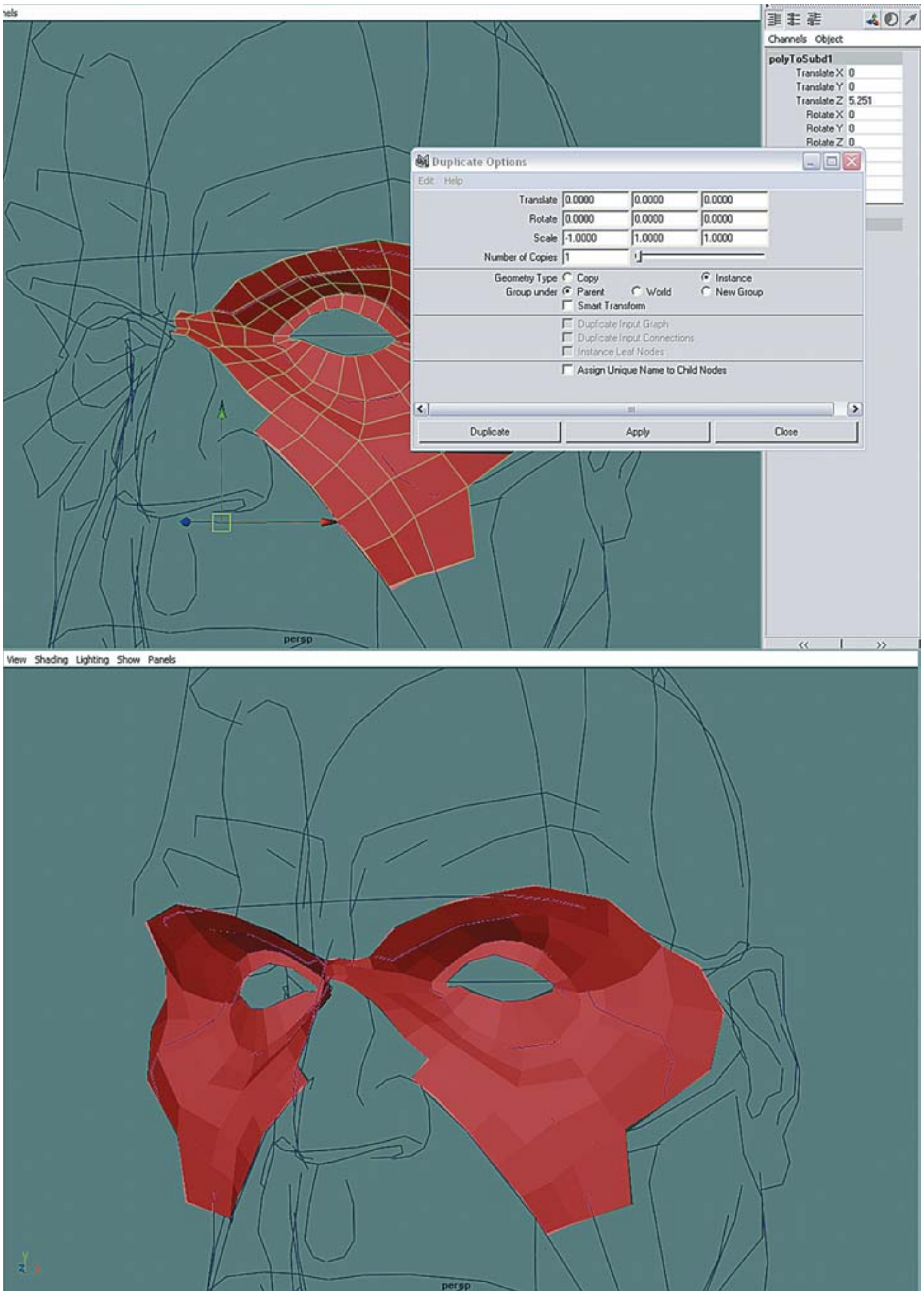


Figure 9.19: Duplicating an instance across the X axis

Continue to use this instanced geometry to view the model throughout the entire modeling process. Only when most of the modeling is done and you are about to convert the entire model to subdivision surfaces can you merge the instance with the rest of the model to make one piece of geometry.

The next area that requires attention is the mouth and chin (see Figure 9.20). This is done the same way as the eye area. Start the rows of polygons as single polygons, and then string them across using the Append To Polygon tool. Model the left side of the character's face; because that's the original, the right side is automatically updated. The mouth is laid in first, creating a template edge for the next row of polygons. The chin is completed, and then the upper lip area is laid in later.

The forehead (see Figure 9.21) and the surrounding areas of the face are tied in using the same process. When joining different areas of polygons, the Append To Polygon tool

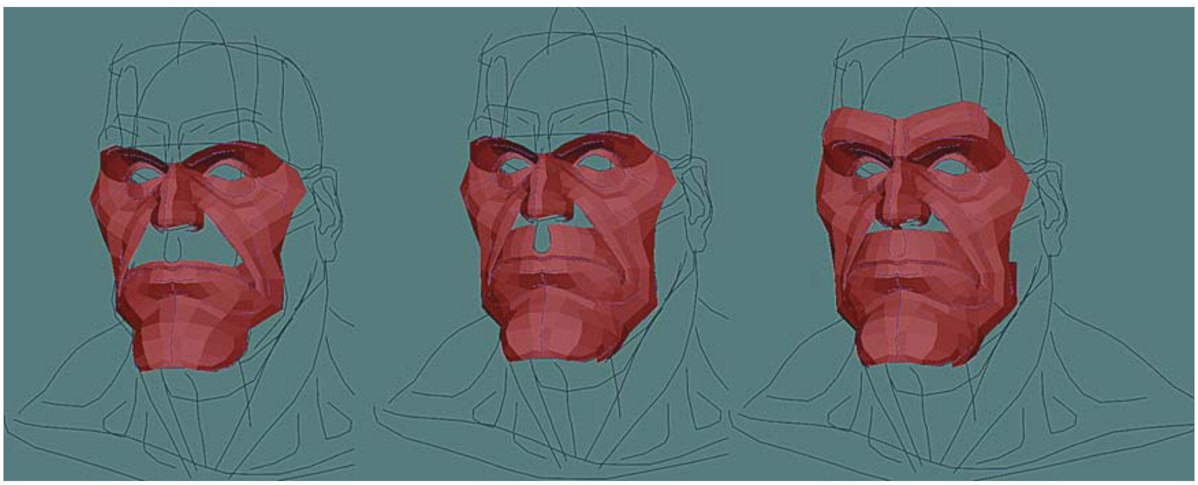


Figure 9.20: The mouth and chin

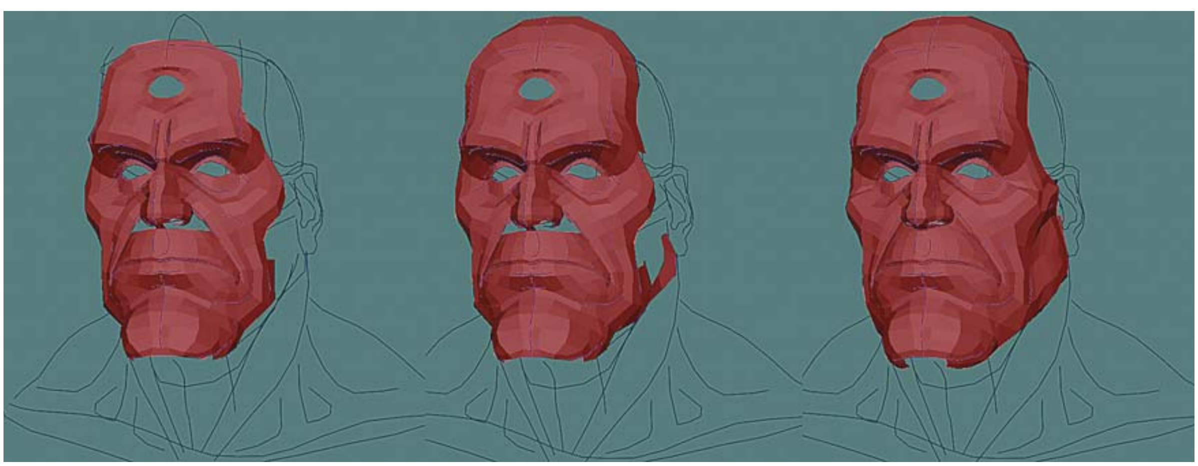


Figure 9.21: The forehead

will require using the Snap To Vertices option, or pressing the V key. Snapping to polygons across the span cleanly creates a bridge where the model forms one smooth mesh.

Splitting Polygons

The wireframe image shows the simplicity of the construction and how the polygonal layout adheres to the original edge loop layout. At this stage, many areas of detail have been added.

Since Maya first introduced the polygon modeling tools, the Split Polygon tool has been one of the most valuable in the modeler's tool box. This tool works extraordinarily well to maintain geometric integrity, while allowing us to significantly change the topology of the model.

> While using the Split Polygon tool, the UVs of the model accurately split and are not deleted. The polygons that are split are not detached, and there are no spurious duplicates of the polygons that sometimes occur when using other tools.

The Split Polygon tool is used through the modeling process to create areas of detail and to reroute some of the polygons in order to avoid triangles and five-sided intersections. When you use the Split Polygon tool in combination with choosing **Edit Polygons → Delete Edge,** you can keep a model's surface intact, but completely change the polygonal layout of the model to suit the needs of animation and production.

To create the areas of detail shown in Figure 9.22, we used the Split Polygon tool to make rows of polygons tighter in areas where natural seams occur along the face. To reduce the number of times the model requires different levels of subdivision, these details need to be as correct as possible. If you want to see the model with the details in place, open `subD_modeling06.mb` on the CD.

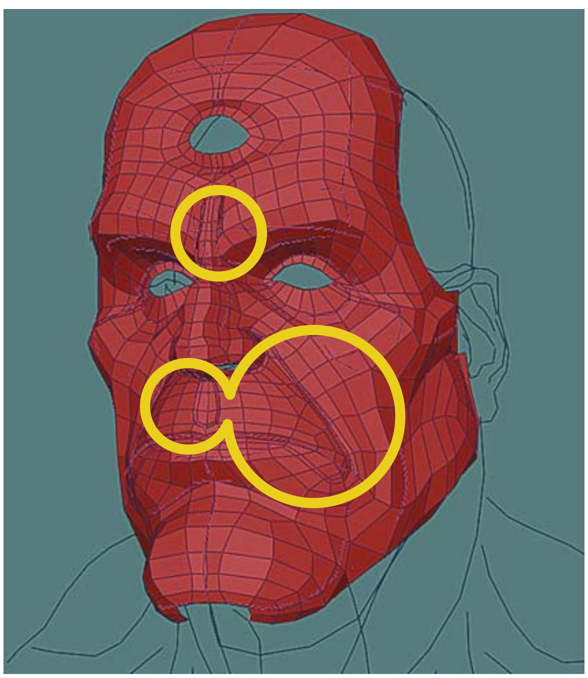


Figure 9.22: Areas of detail

Extruding Rows of Polygons

When the model gets to the point where there are just large areas to create with little detail, such as the top of the head and the neck, the Extrude Edge command is helpful. The next few figures show the detailed step-by-step process of creating extruded rows that will be clean and line up with the rest of the model.

By selecting contiguous edges manually or by selecting one edge and choosing **Edit Polygons → Selection → Select Contiguous Edges** (see Figure 9.23), select a row of edges where the model needs a new row of polygons.

The default extrusion behavior in Maya is to separate every polygon. To make sure the polygons stay together, choose **Polygons → Tool Options → Keep Faces Together** (see Figure 9.24). This forces the extruded polygons to keep the edges together during the extrusion process.

Choose **Edit Polygons → Extrude Edge** to create the row of polygons. This selection displays the Extrude Edge manipulator that you can use to translate, rotate, or scale the leading edge of the extruded polygons. When extruding the row of polygons, make

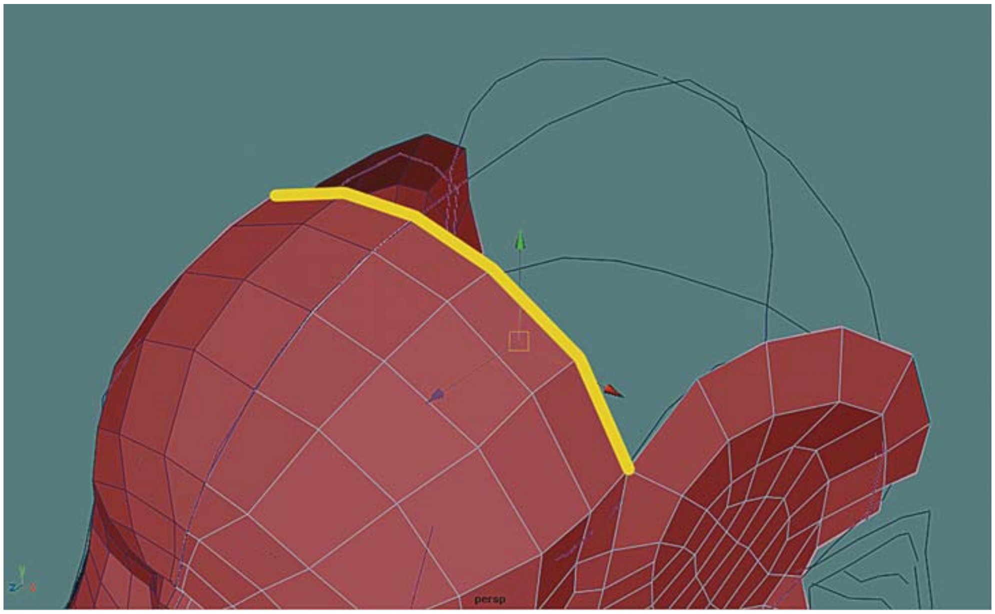


Figure 9.23: Select Contiguous Edges

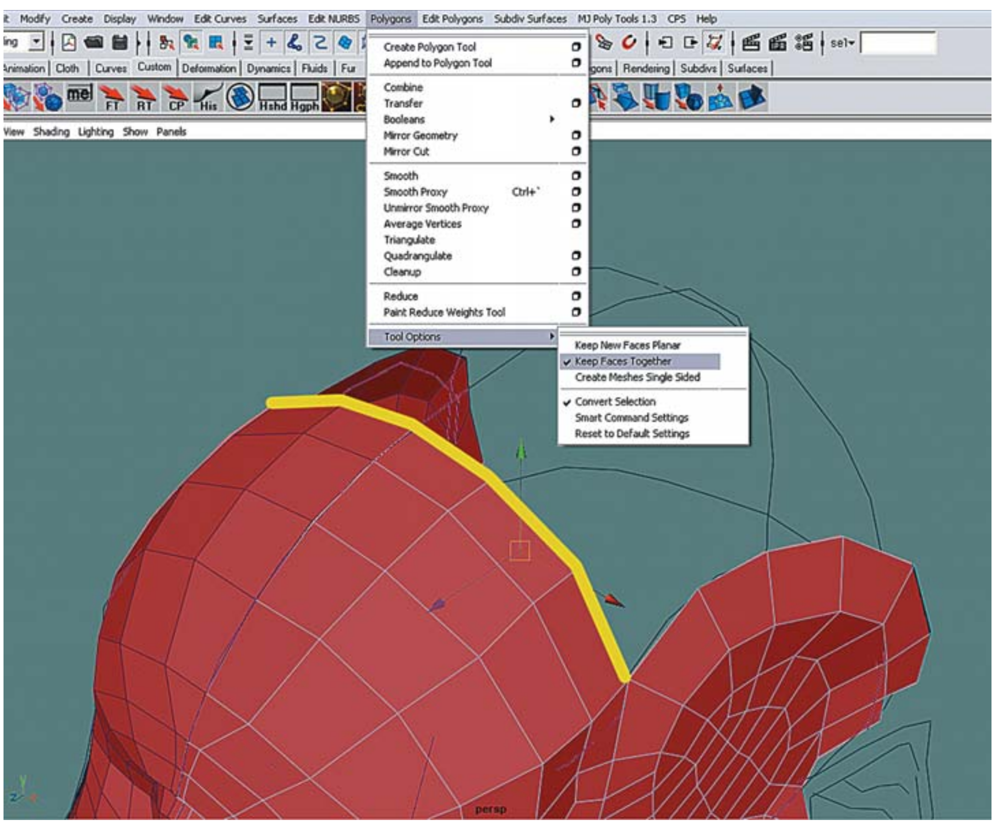


Figure 9.24: The Keep Faces Together option

sure that the row is built as close to the desired final location as possible. The manipulator, shown in Figure 9.25, makes this process as simple as it can be. Any editing that cannot be achieved without using the manipulator will need to be done by hand after the extrude operation is complete (see Figure 9.26).

When the extrude operation is complete, you'll need to weld the vertices at the edges of the polygon row you just created. The last vertex of the row will be disconnected from the remainder of the model and will need to be integrated.

Select the two vertices that need to be welded (see Figure 9.27), and then choose **Edit Polygons → Merge Vertices ❐**. Merge Vertices welds the selected vertices within a given tolerance (the Distance option in the dialog). To ensure the selected vertices are welded, the option for the weld distance is set fairly high. In this case, Distance was set to a level of 10.0.

After you set the options, click the Merge Vertex button to execute the merging process. The finished extruded row and subsequent merged vertex are shown in Figure 9.28.

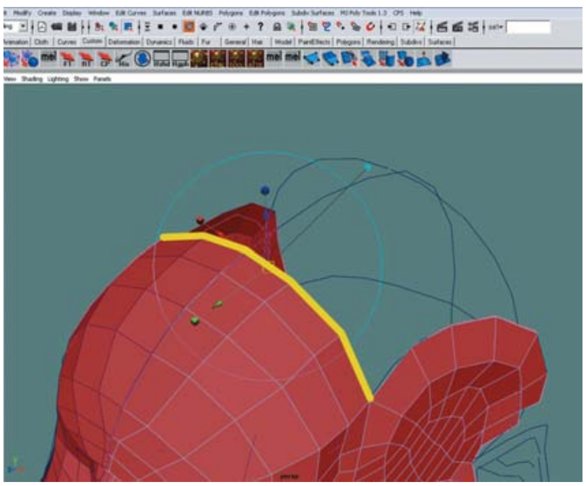


Figure 9.25: The Extrude Edge manipulator icon

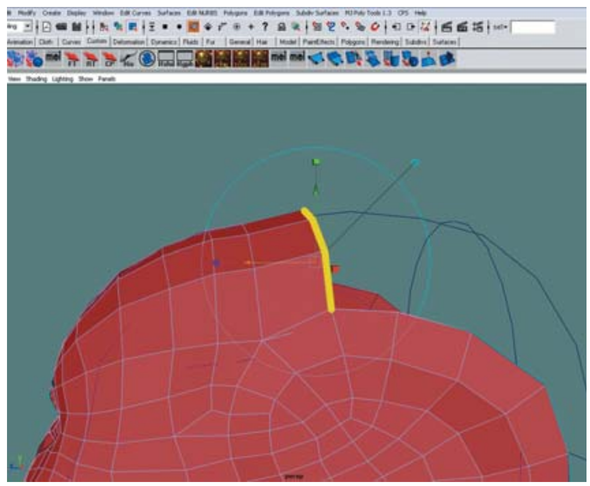


Figure 9.26: Extrude Edge complete

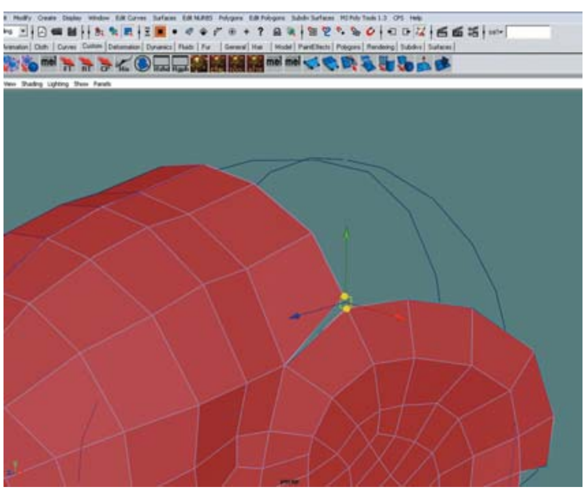


Figure 9.27: Selected vertices

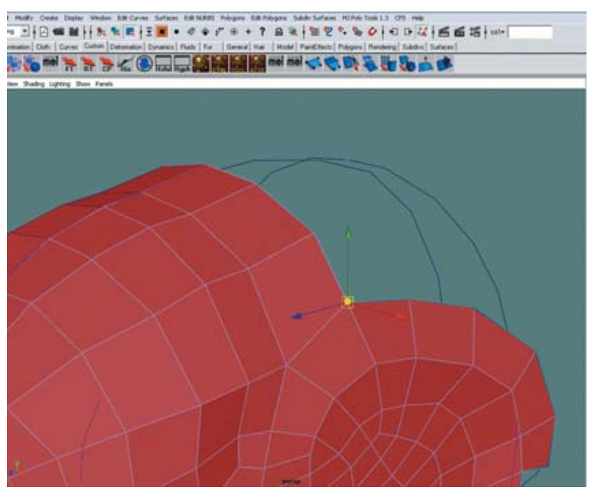


Figure 9.28: Merge Vertices complete

Modifying the Mesh

Several tools in Maya let you move geometry in a subtle way, as if the geometry were clay. In this model, we primarily used the Sculpt Polygons tool (choose **Edit Polygons → Sculpt Polygons Tool**) and the Soft Modification tool (choose **Modify → Transformation Tools → Soft Modification Tool**).

The Sculpt Polygons tool is great for gently pushing and pulling geometry in and out, but one of the most useful options in this Tool Box is the Smooth option (see Figure 9.29). It works by averaging the values of the affected vertices and blends irregular areas out into one smooth area.

Another tool that was introduced in Maya 6 is the Soft Modification tool (choose **Modify → Transformation Tools → Soft Modification Tool**), as shown in Figure 9.30. This tool uses proximity around the selected vertex to control the falloff of the transformation. The curve of influence from the selected vertex to the last affected vertex is clearly drawn out so the user

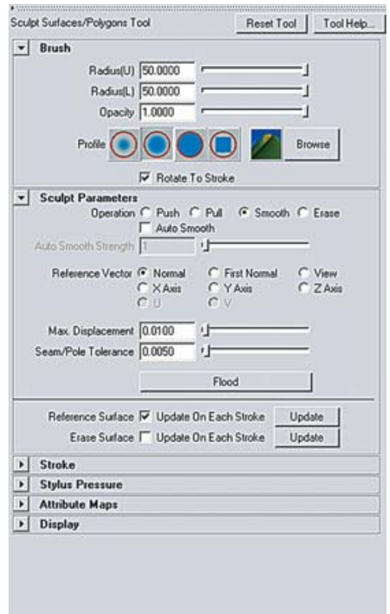


Figure 9.29: The Sculpt Polygons Smooth option

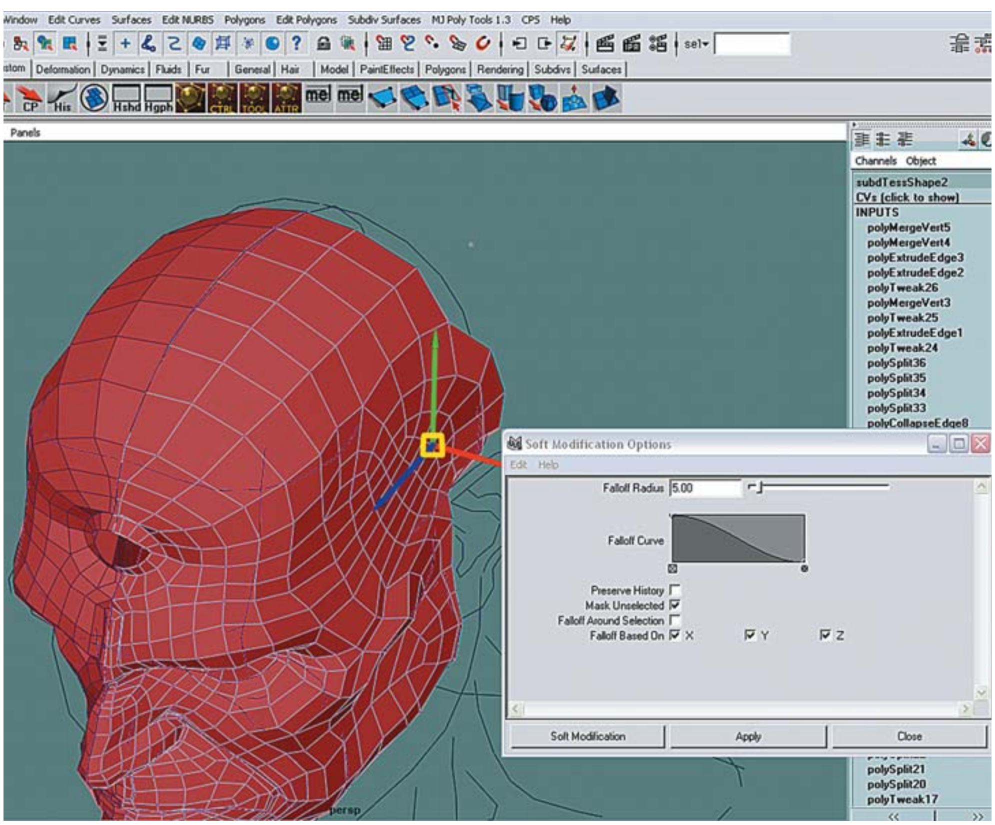


Figure 9.30: The Soft Modification tool options

can adjust the falloff and the amount of intensity the falloff has from the center to the outer edge.

These tools work exceedingly well when used in combination. The smoothing option in the Sculpt Polygons tool prepares the surface by distributing the geometry more evenly, and the Soft Modification tool moves the geometry in a soft, controlled way that the other tools cannot.

Collapsing Polygons

This technique allows us to modify the number of polygons without having to clean up edges and vertices by welding them. The process is simple, but should be thought out carefully before using the Collapse command.

Begin by identifying a problem area in the model. These are places where the model has polygons that are not four-sided or where the flow of the geometry does not coincide with the flow of animation or edge loops. You should reorganize your model's polygon layout to avoid problems later on in production.

Select the edges of the problem areas in the model, and then choose **Edit Polygons → Collapse** (see Figure 9.31).

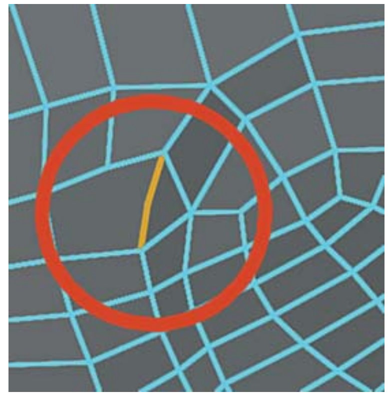


Figure 9.31: Select problem edges before choosing Edit Polygons → Collapse.

The resulting geometry shows how the polygons in that area have been collapsed (see Figure 9.32). The polygons surrounding the area do not have problems with duplicate vertices or duplicate edges. The Collapse command takes care of the cleanup that is usually associated with this kind of work.

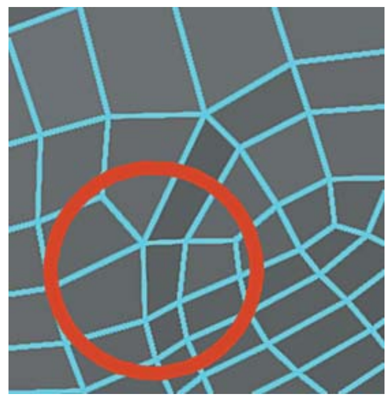


Figure 9.32: The resulting collapsed area

Extruding Polygons

For fast and easy construction of detailed areas, one of the most surprisingly useful tools is Extrude Face. In most organic models, some areas undulate in and out, making conventional modeling difficult. In this section, you'll see several examples of how this command can help when creating detailed areas around the head.

In Figure 9.33, the muscles of the neck are modeled in simple polygons using the Create Polygon tool and the Append to Polygon tool.

Select these polygons, and then choose **Edit Polygons → Extrude Face**. The default behavior for Extrude Face is to divide the faces into separate entities. The separating polygons are not usable and require a lot of cleanup if used by mistake. Be sure the default behavior of the polygon modeling toolset is selected by choosing **Polygons → Tool Options → Keep Faces Together** described in the earlier section "Extruding Rows of Polygons."

Once the Extrude command is applied, the faces appear highlighted with a manipulator present so they can be translated and scaled to fit into the appropriate detail. When you use Extrude Face, the polygons remain cleanly connected (see Figure 9.34). If you do not

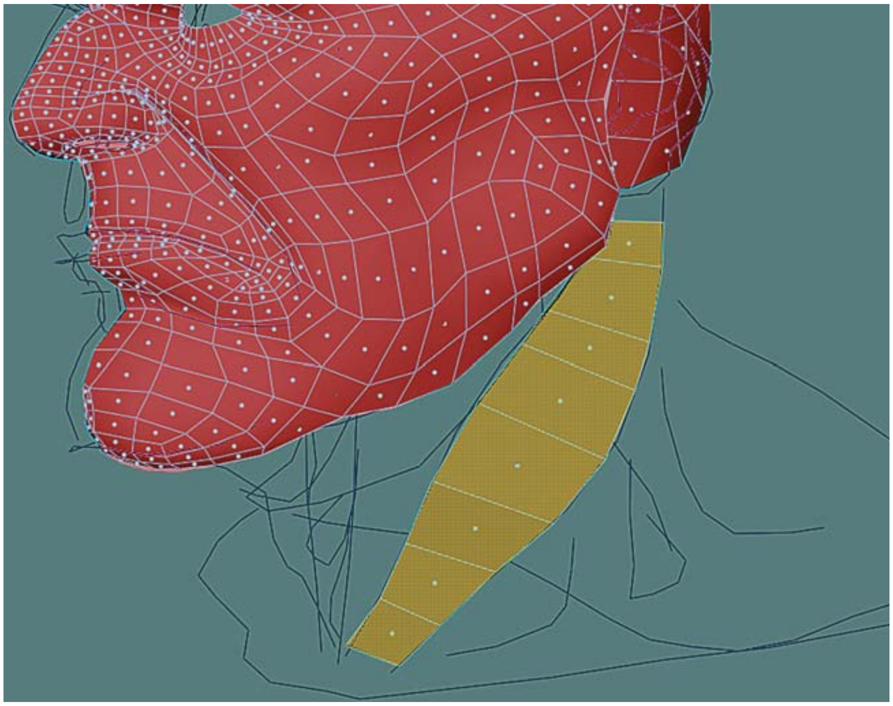


Figure 9.33: Polygons of the neck muscle

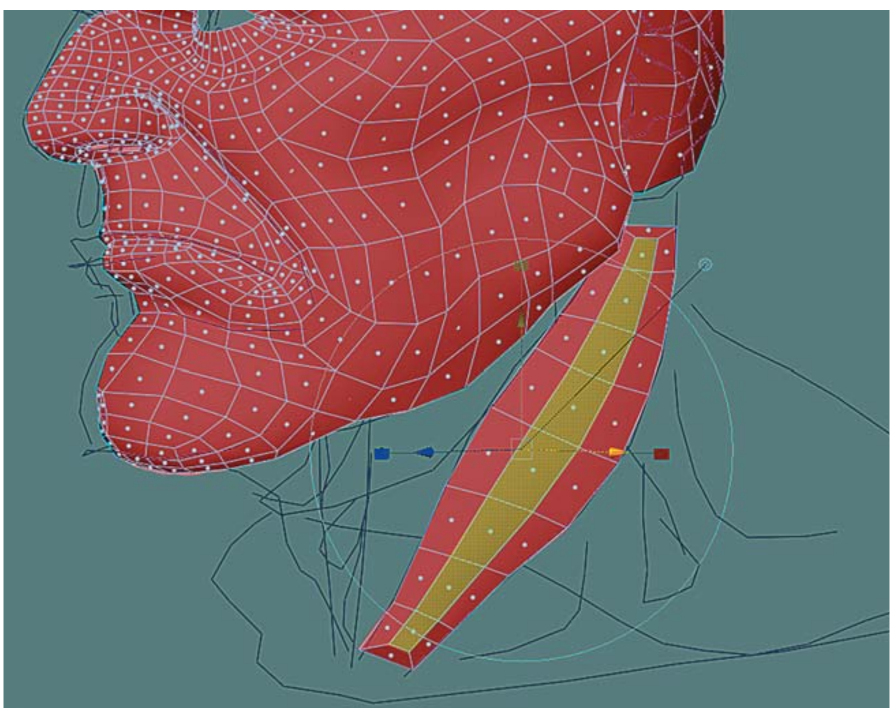


Figure 9.34: Extruded faces of neck muscle

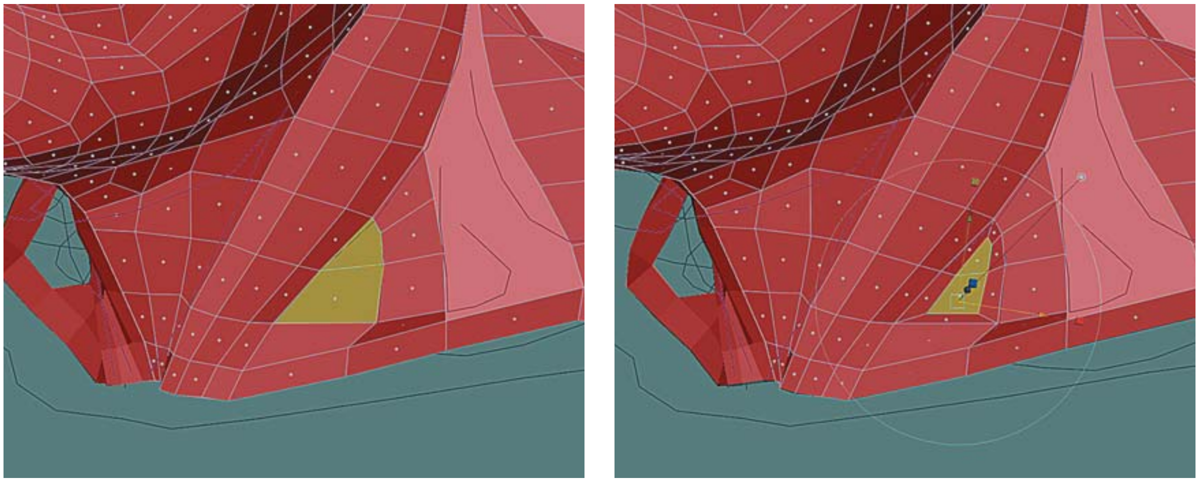


Figure 9.35: (left) Selected faces in neck area 1; (right) extruded faces in this region

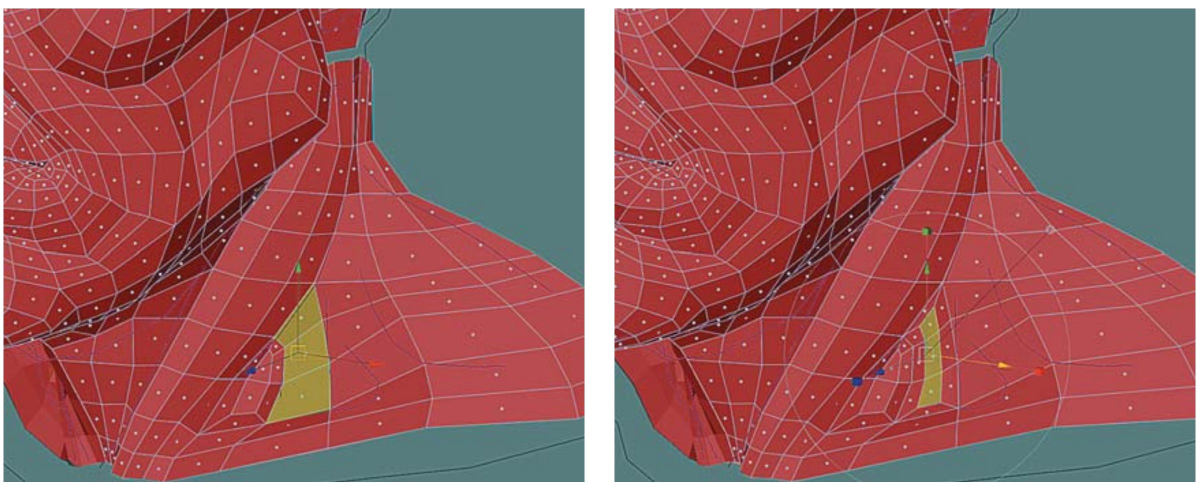


Figure 9.36: (left) Selected faces in neck area 2; (right) extruded faces in this region

correctly set your Keep Faces Together options and the faces separate, undo the operation and start over with the correct options.

This modeling technique is beneficial in many instances. Figures 9.35 and 9.36 are two more examples in which you can use the Extrude Face command in the neck area.

Now that we've described the basic tools, we can get into the specific techniques for building individual details of the model. The parts of the model that make all the difference when viewing the final work are the trickiest. Much of the process involved in the finishing touches of any model are more technique than technology.

Details of the Head

This section uses images that have been collected, showing a step-by-step approach to building each part of the model. The basis for the rest of the construction is in place using the processes that have already been covered, but the tools are used in different combinations.

When you create these areas, it is important to know how these elements are going to look when they are subdivided. To preview the subdivision surface of the model, choose **Modify → Convert → Polygons to Subdiv**. We use this command at this stage of modeling as a way to previsualize the subdivision surface; we won't commit to a subdivision model until the polygonal cage is completed. At the finishing stages of the model, you need to preview the subdivision often. Only by testing the subdivision can we see what the finished version of the model will look like.

The Back Area

You construct the back area by building a single polygon first. Choose **Polygons → Append to Polygon Tool** to create a polygon that goes from the base of the head to the edge of the lower back. Then choose **Edit Polygons → Split Polygon Tool** to split the polygon down the center (see Figure 9.37).

Select the edge that was created by the Split Polygon tool, and translate it to the center of the back (see Figure 9.38). This will serve as the base for the rest of the construction.

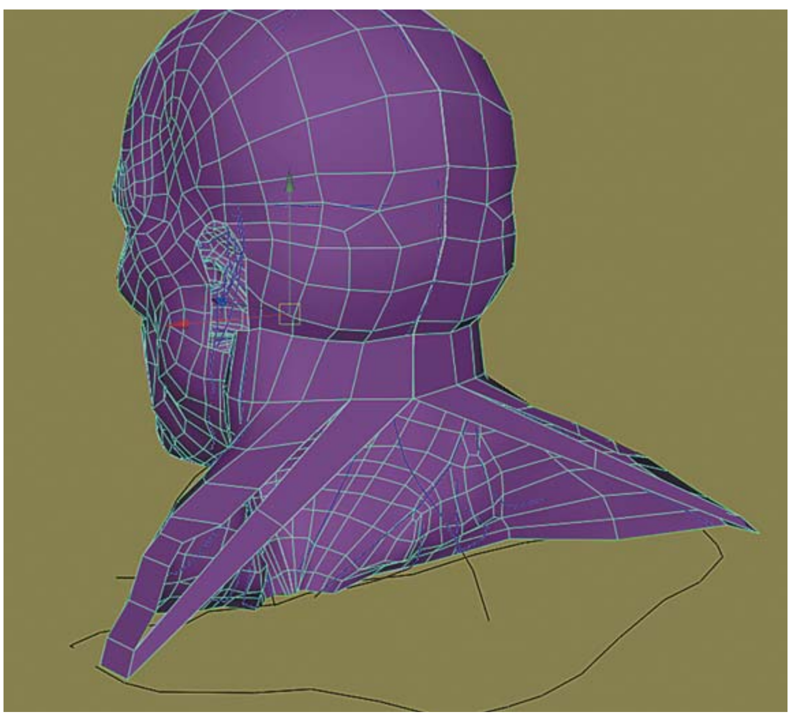


Figure 9.37: A single polygon split in half

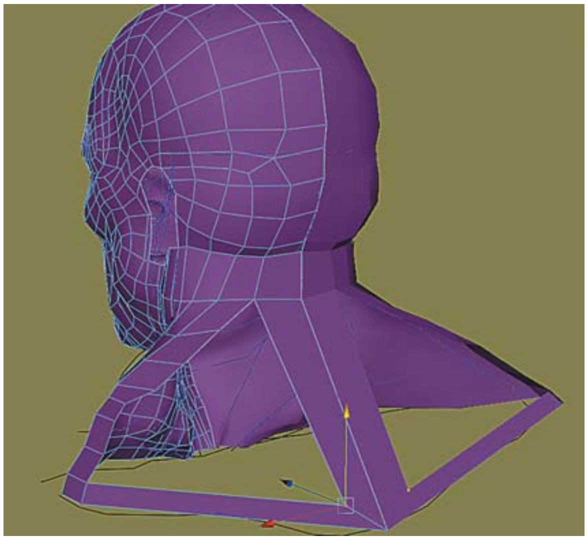


Figure 9.38: The edge translated to the center of the back

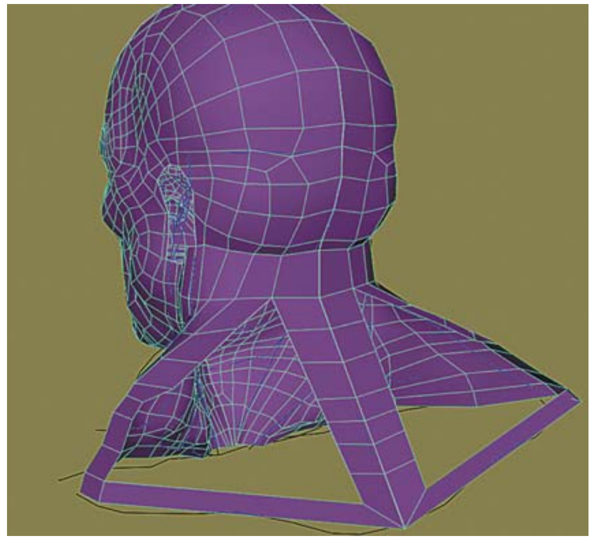


Figure 9.39: The center of the back split into sections

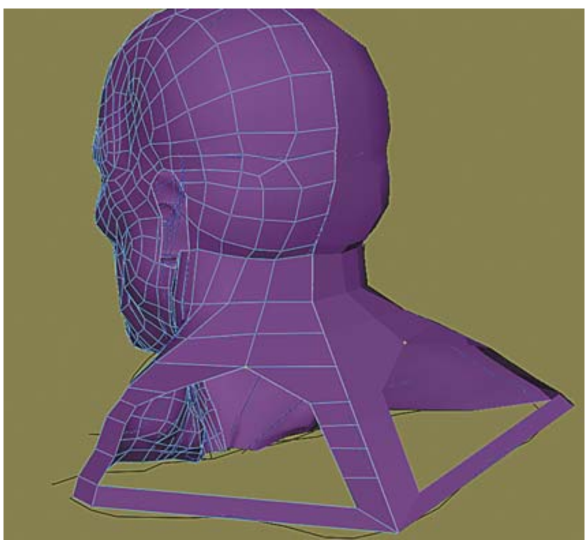


Figure 9.40: Joining the rows of back polygons

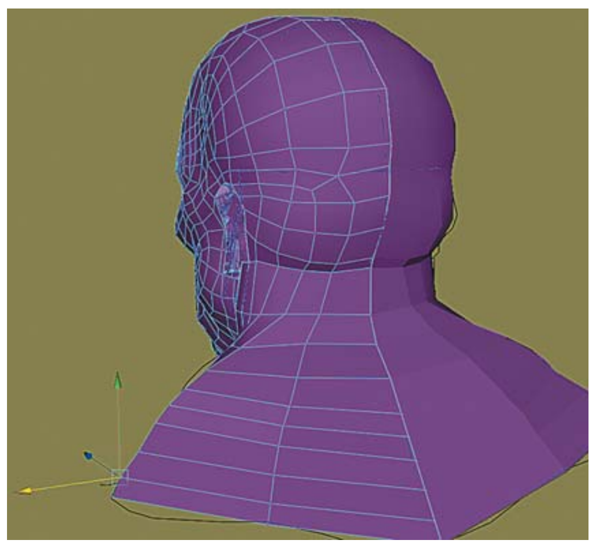


Figure 9.41: The back polygons joined in the center

Use the Split Polygon tool again to give the center polygon the same number of divisions as the edge row of polygons (see Figure 9.39). This sets up the mesh construction for the rest of the back.

Choose **Edit Polygons → Merge Vertices** to join the vertices along the vertical polygon rows (see Figure 9.40). This creates a simple mesh along the back that will become a more complex sculpted mesh.

Join all the remaining edges of the rows using the Merge Vertices command, and split the bottom polygon using the Split Polygon tool (see Figure 9.41). Now the surfaces are ready to become a more complex shape.

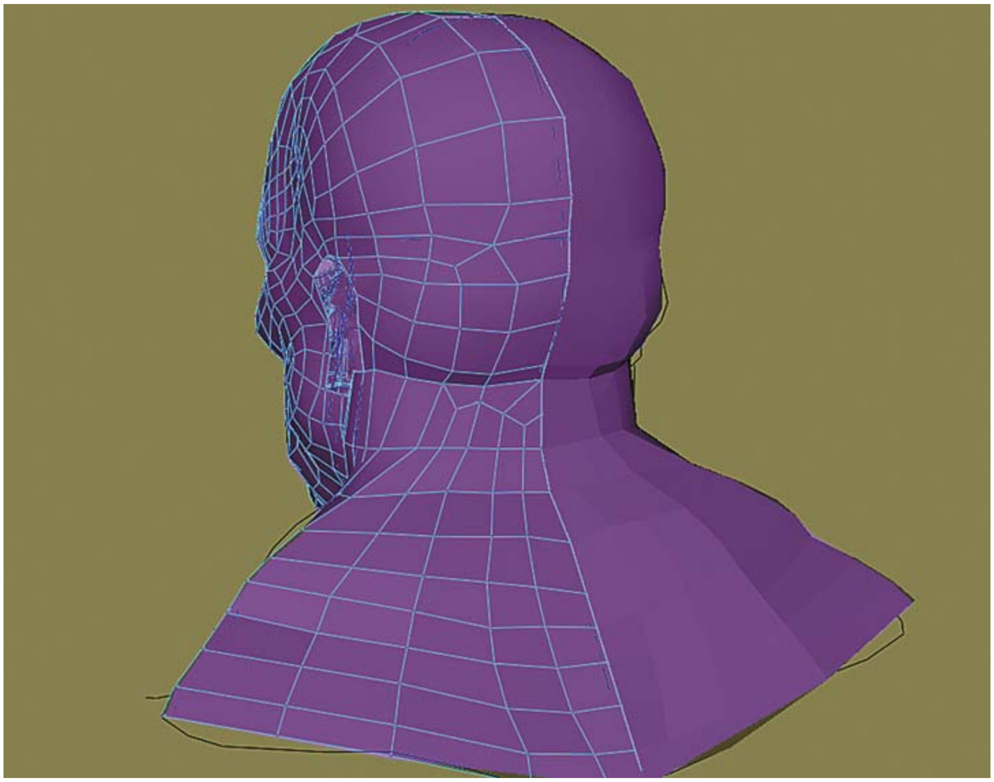


Figure 9.42: The back surface completed

Using the Split Polygon tool modifies the polygon mesh in the back and makes it into a surface (see Figure 9.42) that can be sculpted easily by selecting points and pushing and pulling them into an organic shape. The sculpting process can also be done by choosing **Edit Polygons → Sculpt Polygons Tool** or **Modify → Transformation Tools → Soft Modification Tool**.

The Ear Area

The ear is one of the trickiest parts of the human body to visualize in any medium, and perhaps the most difficult medium in which to capture this complex form is 3D. Using a digital medium or traditional sculpting methods have given artists problems. The only way to really get it right is to work from reference. For the initial construction phase of the ear, turn off the polygonal model's visibility and turn on the image planes. In the side view, use the image planes to trace the outer edge of the ear (see Figure 9.43) by choosing **Polygons → Create Polygon Tool** and **Polygons → Append to Polygon Tool**.

Block in the rest of the details of the ear by creating a single polygon inside the ear (see Figure 9.44), and then choose **Edit Polygons → Split Polygon Tool** to edit the shape. This creates a 2D template for the inside of the ear.

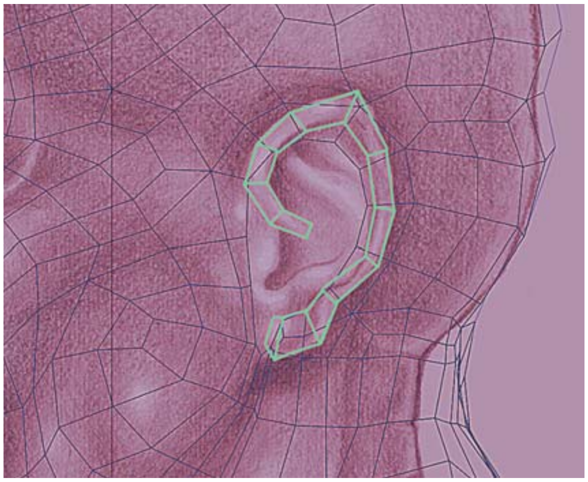


Figure 9.43: Tracing the outside of the ear

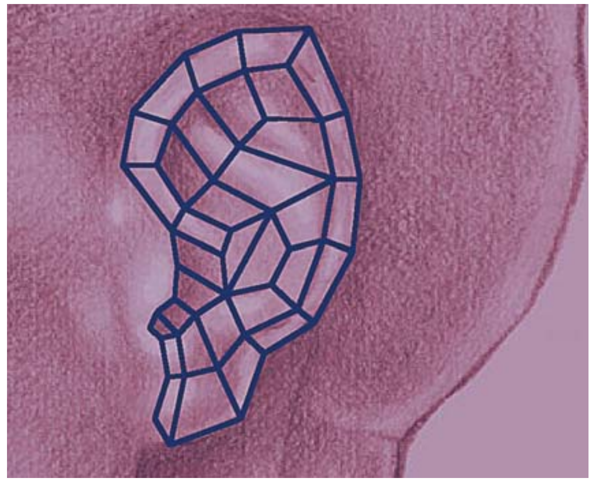


Figure 9.44: Tracing the inside of the ear

Figure 9.45: The ear is translated to the correct place.

Figure 9.46: Adding detail to the ear

The mesh that was created using the image planes in the side view now have to be translated into the correct place in 3D (see Figure 9.45). Using the wire cage that was previously constructed, place the ear in the approximate location where it will eventually go in 3D.

Sculpt the ear model into the correct shape by pulling points. The details of the ear are still somewhat rough. Create additional details (see Figure 9.46) by choosing **Edit Polygons → Extrude Face**. Select the faces that constitute a detail of the ear.

To complete the extrude process (see Figure 9.47), scale down the inner polygons and then translate them in toward the inside of the head. This process creates a clean detail that requires no additional editing.

Figure 9.47: The extrude process to make detail

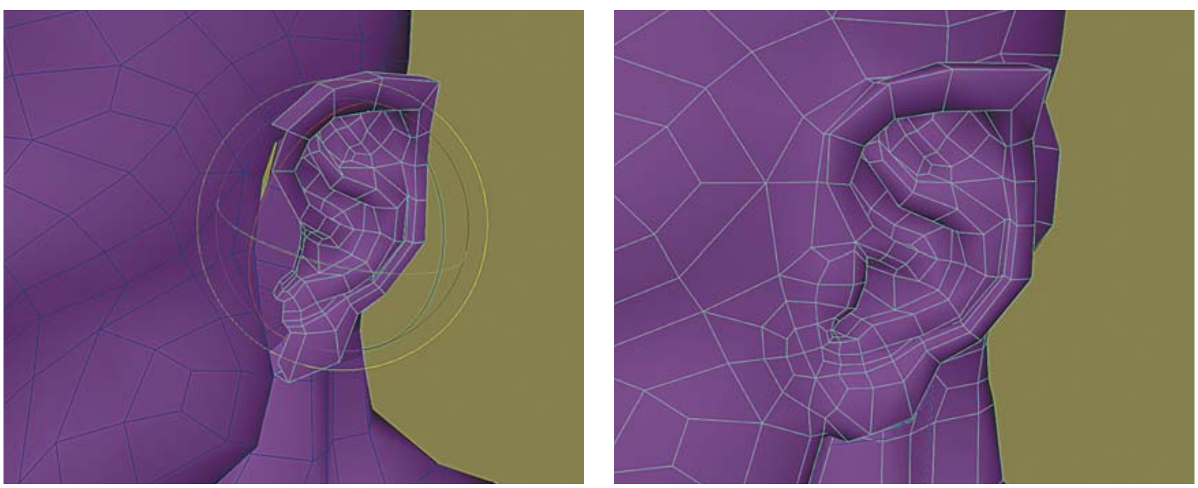


Figure 9.48: Combining polysets before (left) and after (right)

The ear is ready to be joined to the rest of the head. Make the polygonal model visible, and choose **Polygons** → **Combine** to combine the two meshes into one (see Figure 9.48). If you want to see the finished ear, open the `subD_modeling14.mb` model on the CD.

The Eye Area

The basic shape of the eye has already been laid out in previous steps. The rest of the eyelid now needs to be integrated into the face and adapted to an eyeball. Select the edges that surround the exterior of the eye so they can be extruded (see Figure 9.49).

Choose **Edit Polygons → Extrude Edge** to extend the edge of the eye toward the inside of the head (see Figure 9.50). Normally, in an animated model, an entire eye socket is associated with the eye area, but this eyelid detail will suffice for now.

You can add detail to the eye area by choosing **Edit Polygons → Split Polygon Tool** (see Figure 9.51). This creates a smoother transition between the areas of relatively light detail around the eye and the tighter rows of polygons in the eyelid area.

To finish the eyelid area, you must put an eyeball in place. This will not be the final eyeball, but you can use the placement and diameter of this object to create the final eyeball. Create a simple sphere (choose **Create → Polygon Primitives ❒**), and place it correctly to act as a guide to see if the final subdivision is working (see Figure 9.52).

Once the eyeball is in place, preview the subdivision model in order to see the progress in this area. Choose **Modify → Convert → Polygons to Subdiv** to visualize the subdivision version of this model (see Figure 9.53).

After previewing the model, undo the subdivision operation. Continue cleaning up the polygonal model and testing the subdivision by turning it on and undoing it repeatedly before committing to the final version.

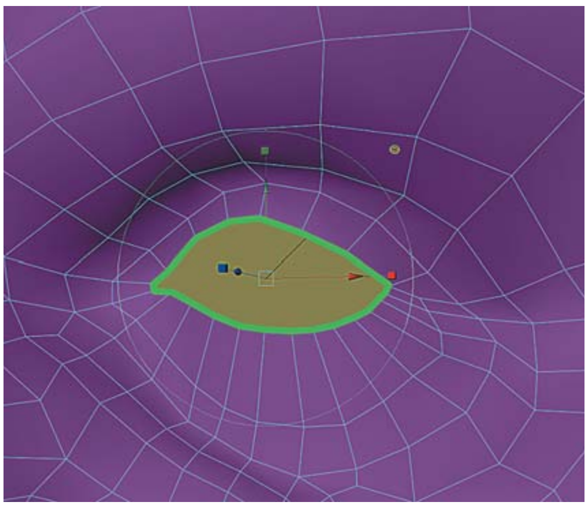


Figure 9.49: Selected edges around the eye

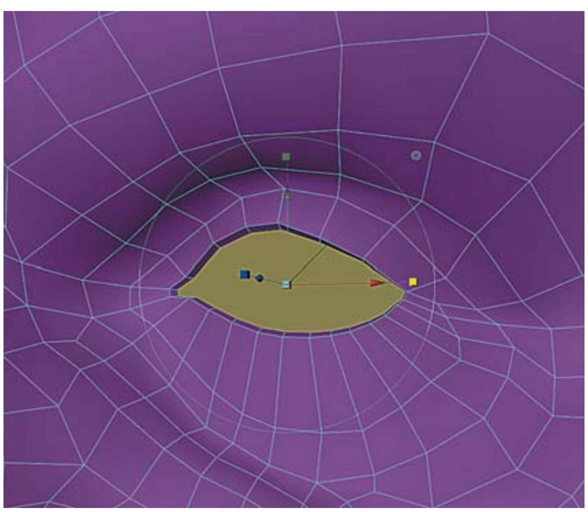


Figure 9.50: The extruded edge around the eye

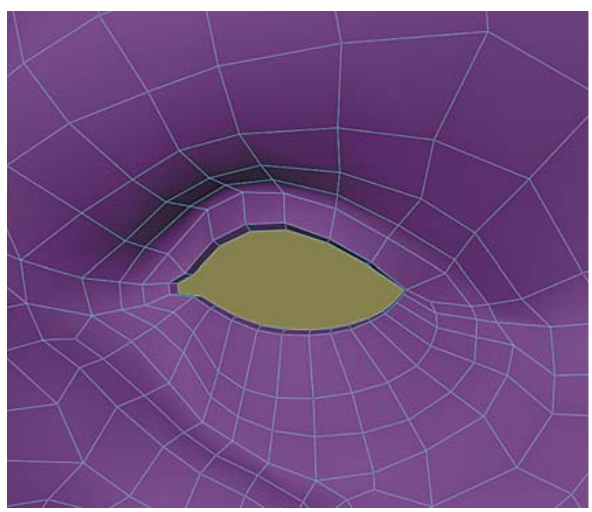


Figure 9.51: Additional detail around the eye

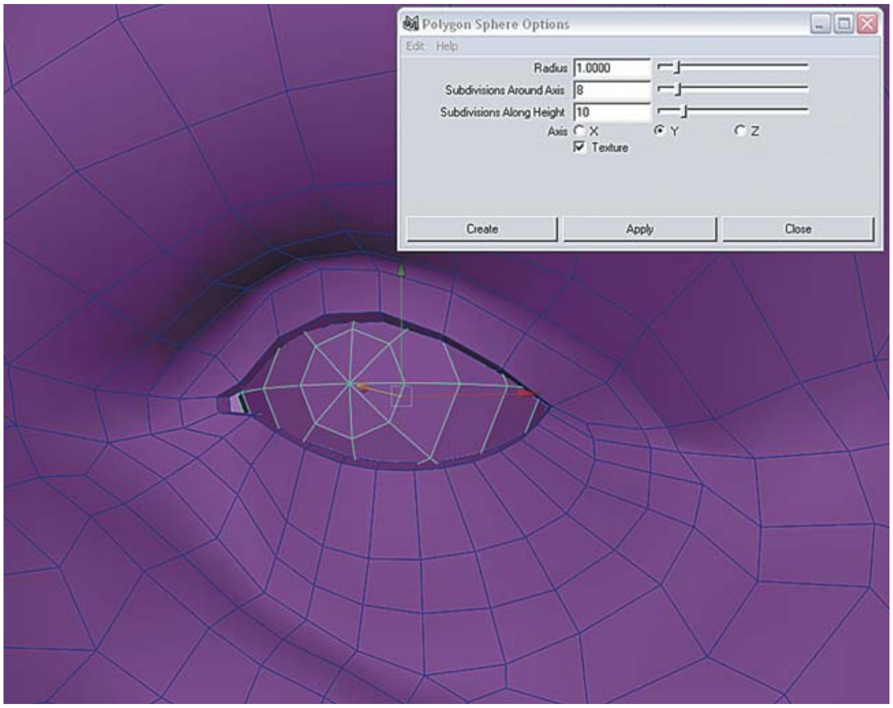


Figure 9.52: Placing and scaling the sphere

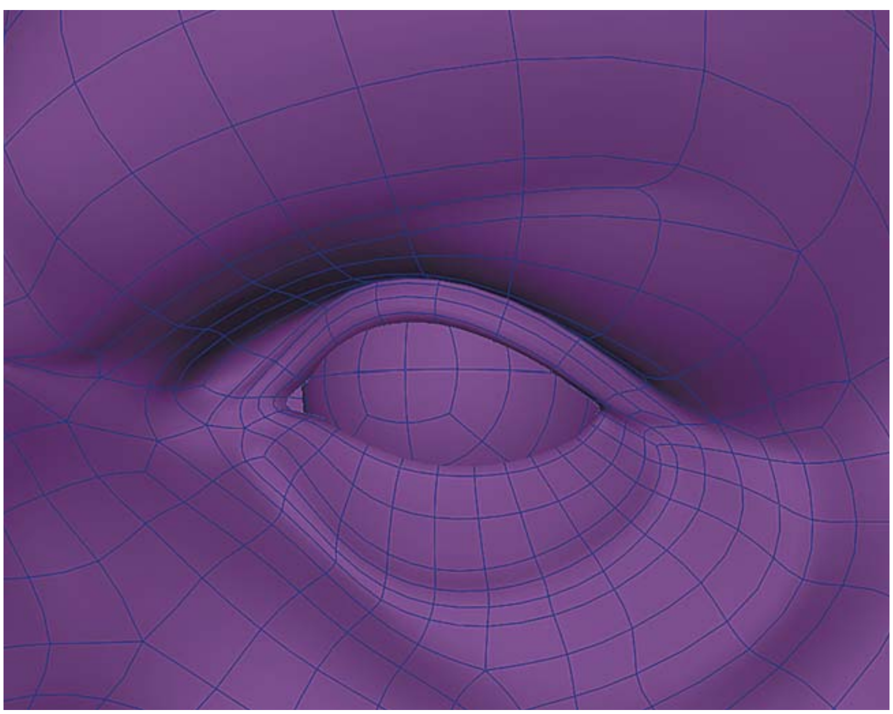


Figure 9.53: Subdividing the model for testing

Creating Subdivision Surfaces

Before you convert the polygonal cage to subdivision surfaces, it is important to delete all construction history. Subdivision modeling can sometimes get slow. Additional history that is unnecessary will make it much worse.

Once the polygon cage is completed to the point where you decide to apply the subdivision surfaces, you can finally merge the two sides of the face. With both sides selected, choose **Polygons → Combine** to combine the two halves into one continuous mesh (see Figure 9.54).

Select the adjacent rows of vertices along the center, making absolutely sure that no other vertices are selected except those that run up the exact center of the model (see Figure 9.55). If some stray vertices creep into the selection set, repeat this step until the selection set is correct.

Use the Merge Vertices command to seal the center line between the two halves of the model. If some errant vertices merge together during this operation, the operation accidentally closes one or more polygons in the model. It is important that this not happen during this step, so carefully check the results before proceeding to the next step. Any accidental problem at this stage will cause many more later.

In our example, we chose **Edit Polygons → Merge Vertices ❒** and set Distance to 0.0020. By choosing only the vertices that you want to merge and using a relatively low threshold for merging, you can help ensure that these common mistakes do not happen. Of course, there is always the tried-and-true method of saving often as an insurance policy.

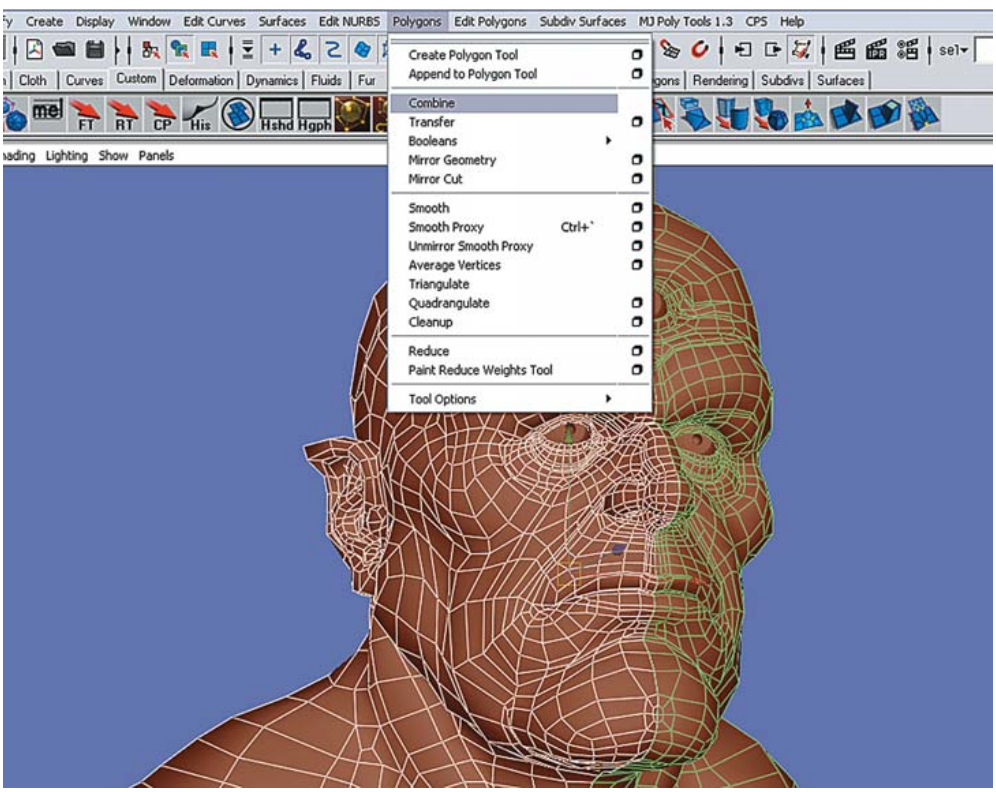


Figure 9.54: Combining the two halves of the head

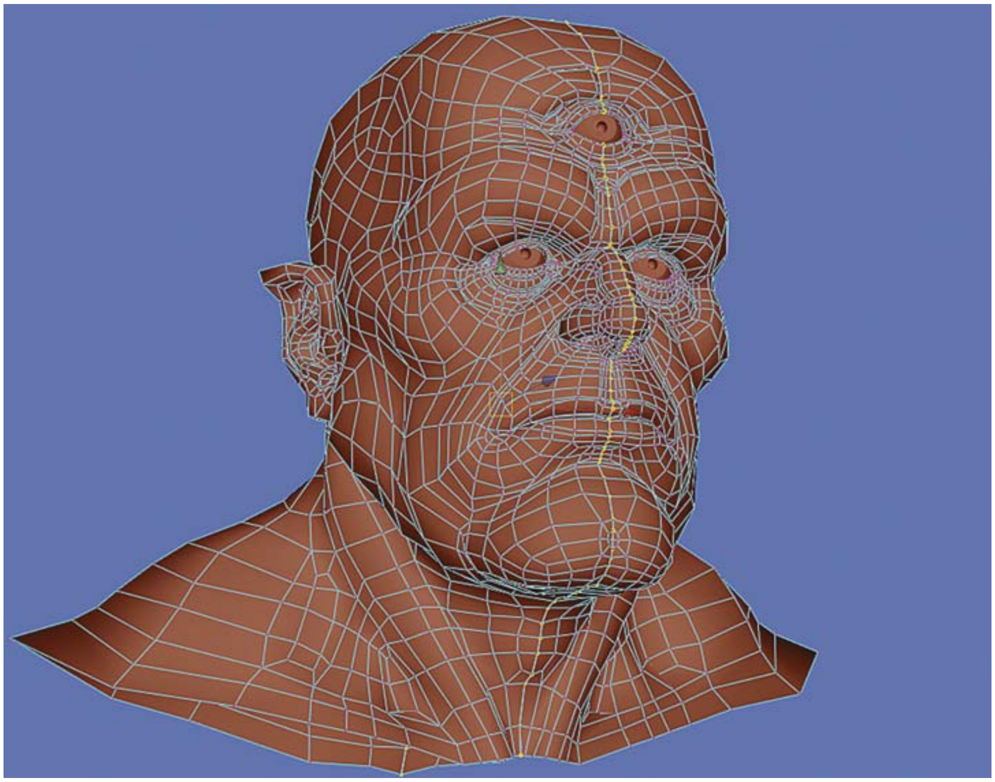


Figure 9.55: Selecting the center row of vertices

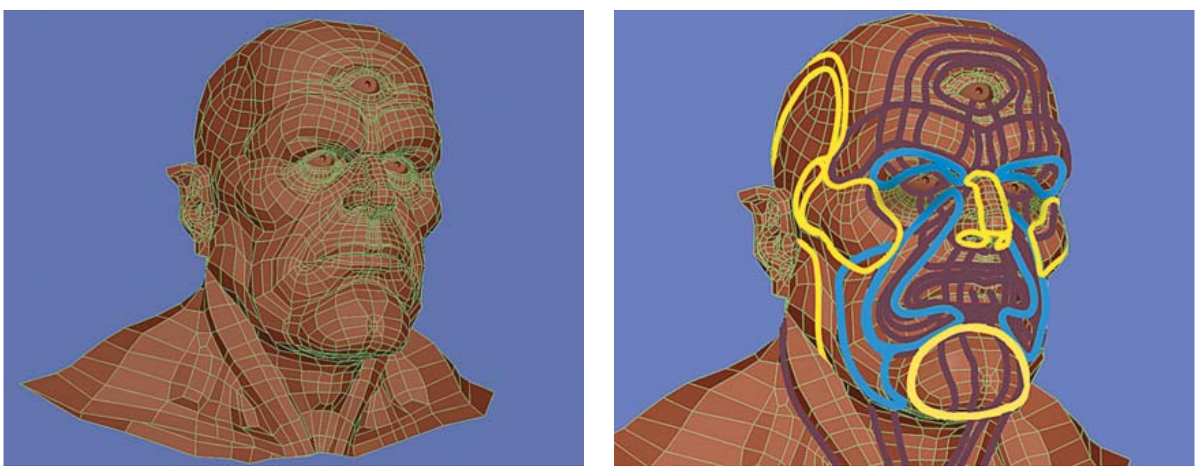
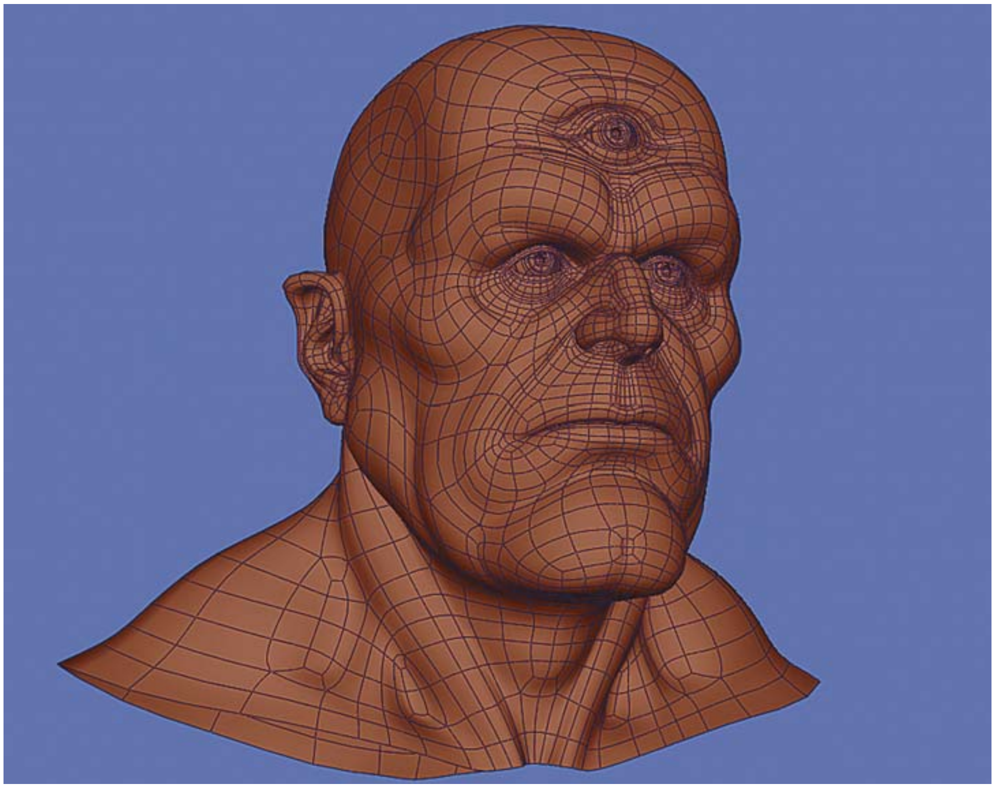


Figure 9.56: (left) The merged polygonal wireframe; (right) the merged model with edge loops

Once the two halves are combined, it is easy to see how the initial planning stages of the modeling procedure have paid off (see Figure 9.56). You can visualize the discussion about edge loops and areas of animation by looking at the wireframe. The original edge loops that were laid out before modeling started can be seen clearly.

Figure 9.57: The converted model



We can now subdivide. We wait to do so until the last possible moment because the subdivided model is slow to work on and time-consuming to update. Choose **Modify → Convert → Polygons to Subdiv** to convert the model to subdivision surfaces (see Figure 9.57).

Here's another, more important reason that the subdivision step is not taken until the last minute: at this stage of the modeling process, asymmetric details are added to the model. Wrinkles and character lines are usually not exactly symmetrical. When these details are added, the model needs to be in a state where it is no longer creating perfectly symmetrical details across its two halves. You add these details using the subdivision modeling layers and modeling options.

Editing the Subdivision Model

Subdivision modeling is just like polygonal modeling, except that the model has levels that can be traversed and the menus are slightly different. Also, just like polygonal modeling, only a limited set of tools is necessary to create a great subdivision model. The rest of the modeling tools are great to use, and you should learn how to use them. But only a handful of the subdivision modeling tools in Maya were used to create this model.

Most of the subdivision modeling that was done on this model was surface editing using the options in the pop-up menus and choosing **Subdiv Surfaces → Partial Crease Edge/Vertex**.

Surface Editing

When modeling in Maya subdivisions, the marking menu (which appears when right-clicking the model) changes (see Figure 9.58). The new options let you edit the model at different levels using different entity types. With a knowledge of polygonal modeling, and an understanding of how subdivision levels work, you can begin to create models with subtle details very quickly.

If you want to add detail at the base level, or the subdivision zero level, choose the **Coarser** option on the marking menu. You can then select vertices, faces, or edges to edit. To work at a finer level or at subdivision level 1 or above, choose the **Finer** option.

The distinction between levels going from coarsest (level zero) to finest (the highest level of subdivision that a modeler would care to set) is how subdivision modeling differs a great deal from polygon modeling.

Notice in Figure 9.59 how the vertices do not display as simple points as they would in polygon modeling mode; they display as the numeral 0. Using a coarser setting allows us to

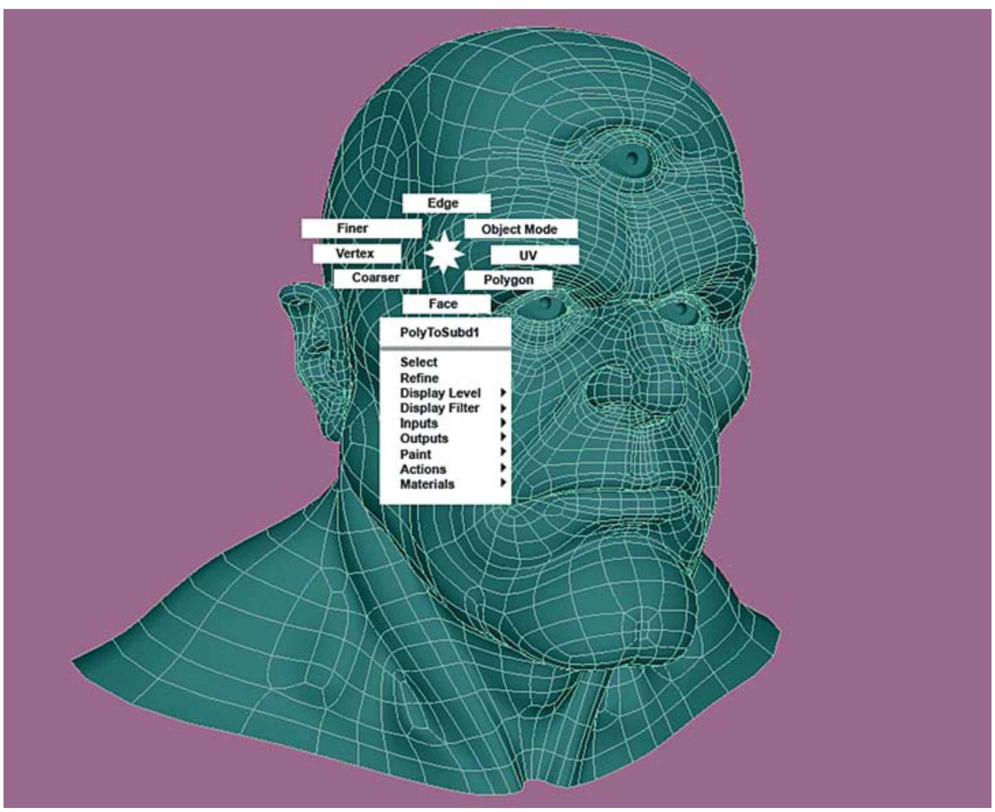


Figure 9.58: The subdivision marking menu

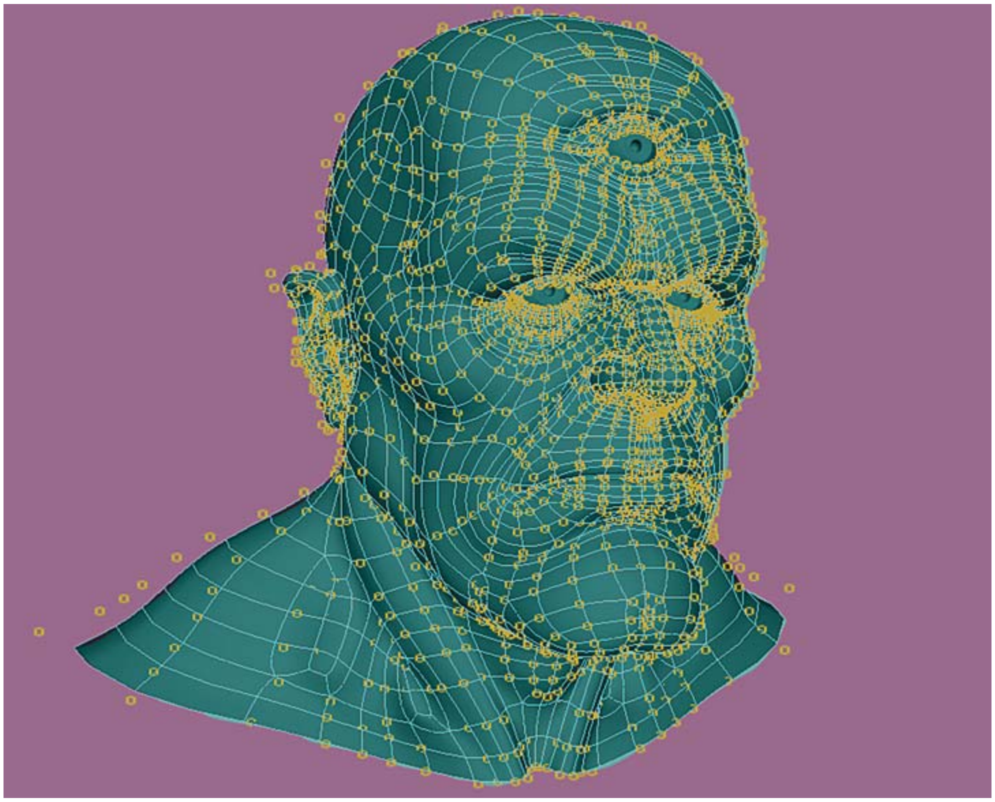


Figure 9.59: Vertices at level zero

affect large areas quickly. Editing in this mode lets the modeler make progress quickly on large areas.

Similarly, the vertices at level 1 display as the numeral 1. Using a setting like this accommodates the creation of small details. The finer the selection, the tighter the details. Editing the surface using a level 1 or finer setting means that we are not making big changes to the model; we're creating small details (see Figure 9.60).

You can edit the edges along a surface in the same way you edit in polygonal modeling mode. The display between coarser and finer levels is an obvious increase in detail that is not designated by visible numerals (see Figure 9.61).

You can see the results of subdivision surface editing in Figure 9.62. The edited figure has many asymmetrical details and many small wrinkles that the unedited version does not. All these small details increase the realism and make lighting and texturing easier, without dramatically increasing the computational requirements of the model. Each subdivision detail is added to a localized region. The rest of the model that is not detailed is not affected by the additional small elements created using this technique. To see the 3D version of the unedited model, open `subD_modeling21.mb` on the CD. To see the 3D version of the edited model, open `subD_modeling22.mb` on the CD.

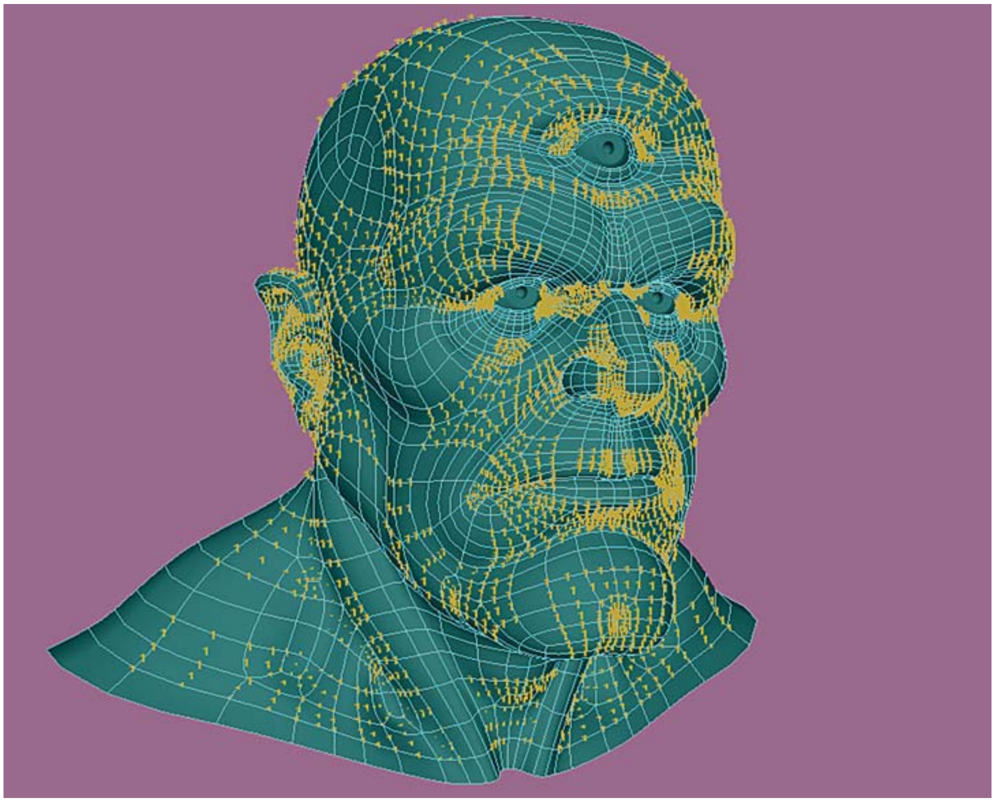
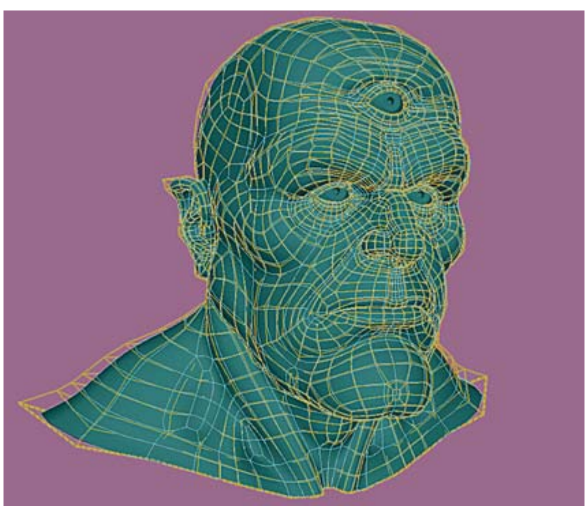


Figure 9.60: Vertices at level 1



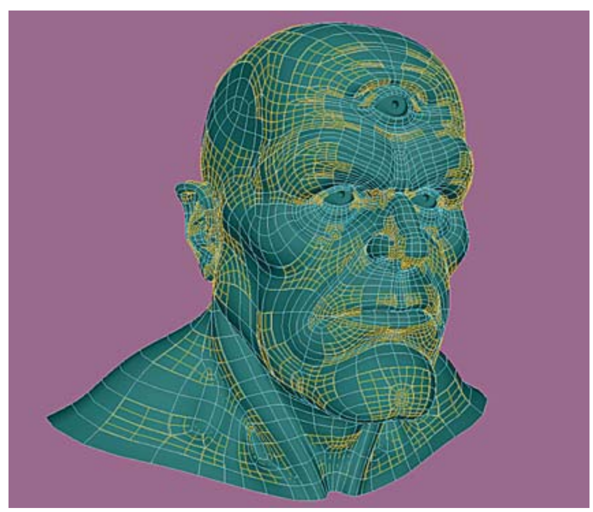


Figure 9.61: Edges at (left) level 0 and (right) level 1

Figure 9.62: (left) An unedited subdivision model and (right) an edited version

Using the Partial Crease Command

Choose **Subdiv Surfaces → Partial Crease Edge/Vertex** to create sharp, angular areas along selected edges and vertices within the smooth subdivision model. If the model needs details that would normally be created by adding geometry, this command adds the detail without adding geometry.

Usually it will not be necessary to go any finer than level 0 to use this command to create creases along the skin of the model. The edges along the lines that require detail are selected first. Figure 9.63 shows the edge of the eyelid highlighted, ready to use the Partial Crease Edge/Vertex command.

The line that was smoothed out now shows a crease where the selected edges were. This line will catch a dramatic highlight when rendered and will create a realistic appearance (see Figure 9.64).

Another area that requires a crease is the line that extends from the side of the nose to the corner of the mouth.

This character line usually animates quite a bit and is not an area where excessive detail should be added. The more complex the geometry in areas like this, the more likely it is that the blend shapes and facial animation rigs will have problems.

Using the Partial Crease Edge/Vertex command is a perfect choice for creating this detail. As in the example shown in Figure 9.64, the edges along the area are selected before the command is executed (see Figure 9.65).

When the command is executed, the line along the face is perfectly tightened. Using conventional polygon modeling methods would make this process difficult and complicated. The Partial Crease Edge/Vertex command simplifies the modeling in these areas a great deal (see Figure 9.66).

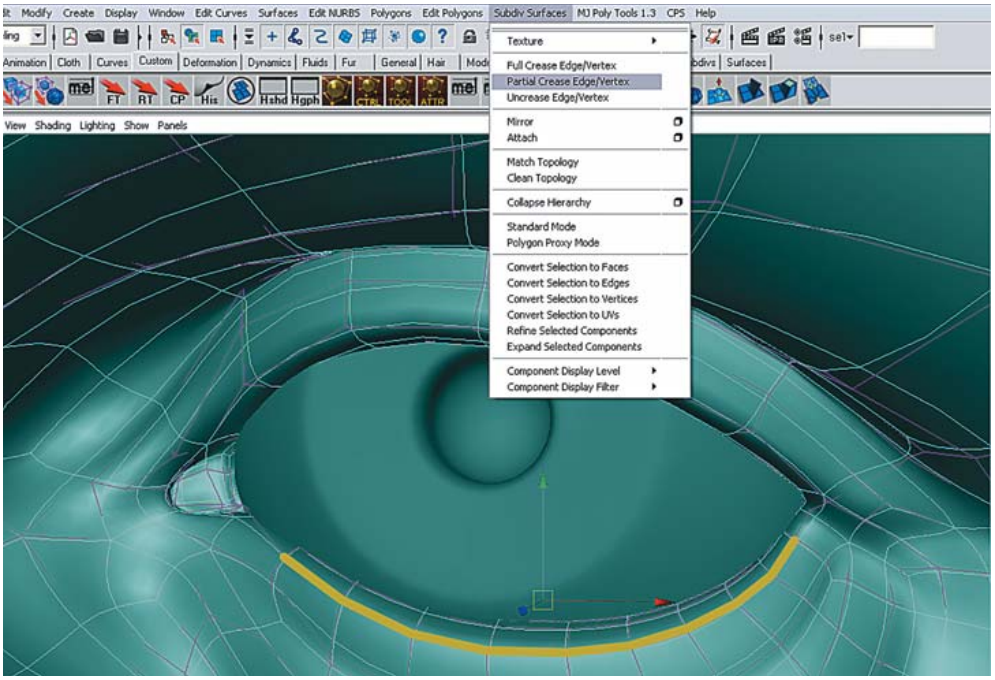


Figure 9.63: The eyelid line selected for the Partial Crease Edge/Vertex command

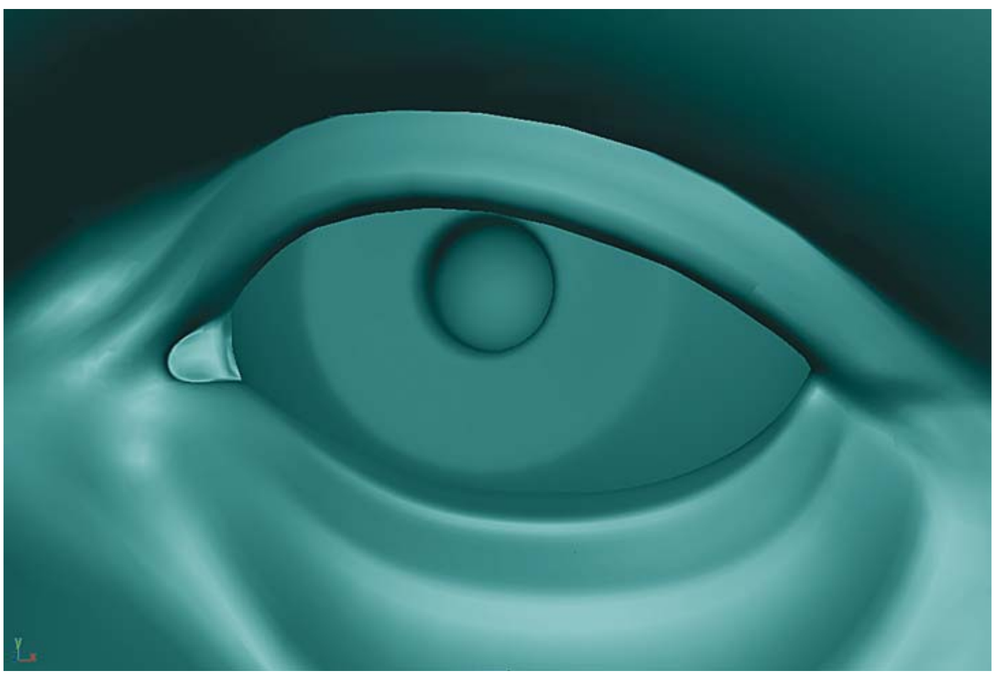


Figure 9.64: The eyelid highlight line

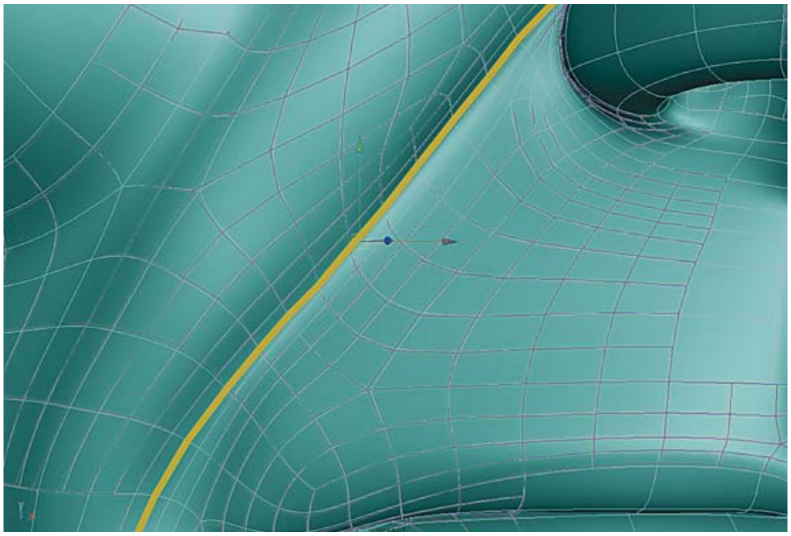


Figure 9.65: Selected edge along the side of the face

Figure 9.66: Finished crease along the face

And our final model shows the results of our detailed work (see Figure 9.67). If you want to see the model in 3D, open `subD_modeling_final_details12.mb` in the CD.

Always Learning

We covered a lot of ground in this chapter—the process of creating a wireframe cage from an edge loop layout, the process of using the polygon-by-polygon modeling technique to create an organic model, and the process of using subdivision levels to create degrees of details. Subdivision modeling is quickly becoming the industry standard for creating beautiful organic models. These techniques are powerful and fast and are far superior to the techniques that preceded them.

Figure 9.67: The final model

The problem is, digital art is like a moving train. To remain on track, we have to stay in front of it. These techniques are great, but something else may come along that will make these techniques obsolete.

In the end, you—the modeler, the artist—must be the one who makes the model great. You create the subtle form of the details of the face, the overall shape of the head and neck, and the little surface tweaks that bring the flesh to life. The tools in Maya are only the pencils and paintbrushes in your tool box; they cannot make the model great by themselves.

If you use the tools explained here, you will be able to develop more imaginative creations than those you developed using the tools that you have been using before. The flexibility and speed of polygon-to-subdivision modeling can help you make your creative visions truly come to life.