In this article, you will be introduced to the concepts, goals and techniques needed to diagnosis surgical cases, when surgical cases should be started and how to gain the knowledge needed to create successful results.

We'll delve into joint status, soft-tissue analysis, surgical treatment objectives, pre-treatment surgical setups and surgical setups. We'll then follow-up by looking at the concepts of natural head position, the axis-horizontal plane and the true vertical line will be introduced. By the end of this article, you should have:

- An overview of the knowledge needed for successful treatment.
- An introduction into what, when and how to perform successful cases.
- An overview of joint health.
- A summary of the soft-tissue analysis.
- An outline of the surgical treatment objective.
- An overview of diagnostic and surgical setups.

Remember that this article is an introduction only; it's not intended to teach you how to do surgical cases. Advanced training will be needed to master successful orthognathic surgical cases. So with no further ado, let's get started.

Functional occlusion

The goal is to obtain functional occlusion. Before treatment, you have to determine if you have an orthognathic surgery case. You don’t want to begin orthodontic treatment with the idea that if orthodontics fails, we will do surgery.

You’ll see in Figures 1–3 that this case involves every facet of dentistry. Changes occurred not only in the facial features, but also in the teeth themselves. It involved orthodontic and orthognathic surgery, but also lengthening the front teeth by the restorative dentist to achieve the natural smile in balance (Figs. 1–2). To this end, we need to look at five areas:

- Joint status,
- Soft-tissue analysis,
- Surgical treatment objective,
We'll give you a brief overview of the goals for each of the areas, then do an in-depth look into each of them individually.

_Joint status_

Starting with the first area, you need to know the joint status. Is the joint healthy, is it degenerating, is there a disc problem? This means you'll need to apply not only a good clinical exam, but also articulated models that can measure the difference between centric occlusion and centric relation.

_Soft-tissue analysis_

You'll need to know how to analyze the soft tissue. You'll need this because you are looking at everything from a soft-tissue standpoint, or put another way, you're recording the basic measurements that come from soft tissue, not hard tissue. If you deal with hard tissue only, then you will come up short in the soft tissue. Ignoring the soft tissue will result in a face that's not improved, just different.

_Surgical treatment objective_

You need to know how to do a surgical treatment objective. You'll need to know the technique, and you'll need to know how to apply it because the surgical treatment objective allows you to treat the face, the occlusion, in a two-dimensional medium.

_Pre-surgical setup/surgical setup technique_

Once you have established what you'll need to do from the surgical treatment objective, you will need to do what we call a pre-surgical setup. Otherwise you'll need to apply the knowledge you've gained from the patient, soft-tissue analysis and the surgical treatment objective, and perform a three-dimensional workup to make sure what you have planned will work with the joints, muscles and nervous system.

_Surgery_

Finally, you need to know surgery. I recommend that the orthodontist be in the operating room so you know what the surgeon is doing, and how the surgery goes. It's very important to know that the surgeon gets the joints seated in a passive manner. If the joint is stressed, then there's a good chance that we'll have some surgical relapse.

_Joint status_

Joint analysis will include three portions: history, a clinical examination and imaging.

Building a history will be similar to traditional patient assessment. We need to know if there are any family members who exhibit TMJ problems. If yes, then there's a good chance the patient will develop significant joint issues that will affect the outcome of treatment.

After an oral investigation, a thorough clinical examination of the joints will need to occur. We'll be on the lookout for any type of injuries to the mandible. If the patient has had any injury that involves the chin, there's a good chance that the joint may have been damaged.

Finally, we need to look into any past treatment. Has the patient had orthodontics before? Has the patient had a lot of restorative dentistry? This is important because all of the above have a tendency to affect joint status.
Clinical examination

Next is the clinical examination. Clinical examination includes the following:

- Range of motion,
- Symmetry of jaw motion,
- Palpation,
- Auscultation,
- Muscle splinting,
- CR position.

Range of motion should be between 45 mm and 55 mm on opening and includes assessing movement. We're looking for a symmetrical mandible motion—meaning the chin should not deviate to the left or right on opening—and it should be relatively free of dental interference.

Now check for palpation of the muscles of mastication. If you don't check the muscles that move the mandible, then there's a good chance that you'll miss some sort of functional bite issue.

We also listen to the joint with a stethoscope, and we apply some anterior pressure to the disc through external auditory meatus to make sure the disc is functioning properly.

When trying to manipulate the mandible, one can feel the muscles. If the muscles will not let you obtain a centric joint position, then we cannot do a diagnosis because the muscles aren't holding the condyle out of the socket. This is usually due to some inflammation.

Finally, we'll check what we call the centric relation position, which you should be able to feel. It should feel solid and the patient should be able to open from this position with relative ease, and there should be no noises.

Imaging

The clinical examination will tell us a lot about the joint status. The use of imaging will help us build our base of case-specific intelligence. We'll use two types of imaging: MRI and cone beam.

LCBCT

Most of the time, we start with cone beam because it's easy to obtain a 3-D image of the joints.

Thanks to the work of Rickets and Dr Ikeda, we have a way to measure joint position and get an idea if the condyle is basically seated. With cone beam, we can measure the health of the condyles.

Our imaging showed a joint that is in a state of degeneration. The condylar head has changed in vertical height. Therefore, we would expect to see an asymmetrical opening in which the chin deviates to the affected side. In all three views (sagittal, coronal, and axial), we have a condyle that is actually changing, especially when you make a comparison to the left condyle (Fig. 3).

In a side-by-side presentation, you can see that the left side is definitely in a lot better shape, having a more rounded effect to it. The size of the coronal view is one that shows a definite symmetric outline to it as compared to the other side. The axial view confirms this; you see that the shape is better and has a more dense outline.

Thus, our basic imaging system helps us determine that, in this case, one side is going to be the problem side, especially as it pertains to orthognathic surgery.

If we go to the two-dimensional images created in the cone beam, we can see that the right joint has definitely lost vertical height, and we definitely have a joint spacer that is excessive (Figs. 4 & 5).

In the coronal view, we can even see that there may be some sort of cyst formation. When you compare the right side to the left side in the coronal view, you get a more traditional image, which is what we'd like to see. However, there have been some changes that have occurred, because we're starting to see a "bird-beaking" effect in the left joint. The images of the joint are ones that are important in determining if we should proceed with any kind of a surgical correction.

In the sagittal view, the right side, the joint looks pretty normal. However, if we look at it in a transverse direction, you'll see less joint space laterally than you do medially, something we see in both the left and right joints (a much bigger joint space). That's why it's important that you not only look at a sagittal view, but you also need to look at the coronal view to see if you have a transverse problem occurring in the joints.

Soft-tissue analysis

When we're trained in orthodontics, we're trained in hard-tissue analysis, otherwise all of our cephalometric analysis are based on hard structures.
If you use hard structure to determine soft-tissue corrections, then you’ll come up short of good facial aesthetics. That’s why a soft-tissue analysis is so important.

Using soft-tissue markers with 3-D facial mapping, we are able to diagnose the soft tissue, and we can also relate it to the hard tissue.

In Figure 4, we've overlaid the soft tissue on top of the hard tissue. With the markers on, after we convert it to a two-dimensional X-ray, we can see where the sub-pupall area is, where the cheekbones are and where the alar base is. In addition, you will see a marker that we call a hinge access marker, which comes from establishing the true hinge axis of the patient. There is also a marker that's placed on the nose that we call the horizontal point.

We are going to analyze everything from a basic coordinate system of a true vertical to an axis horizontal.

The image is orientated from the axis horizontal plane and the true vertical plane, which is based on the patient’s natural head position.

Figure 5 shows how these two corners are at 90 degrees from each other. In this analysis, we're going to record all the soft-tissue measurements, both horizontal and vertical, and we're going to base them on the line that runs through the subnasale (SN). This establishes the true vertical line based on natural head position.

Furthermore, we're including a few hard-tissue measurements that will tell us about the architecture of the mandible. These come from Rickets and from the Jarabak analysis. With this analysis, we can cover the basis that we need for orthodontics, but we can also cover what we need in a surgical workup.

We also need a frontal analysis, which is taken from the patient's face. Most of the frontal workup is done in examining the patient clinically. This enables us to look at the orbital rim, cheekbone, sub-pupil, alar bases, nasal bases and canthus of the eyes.

All of this enables us to assess if we have transverse asymmetries, where the occlusal plane is canted instead of level. This also holds true with the mandibular plane, which we may also find is canted. This is especially true in cases where there's a degenerative process happening in one joint.

**Head position, profile and frontal analysis**

The natural head position is different for each individual patient. This will make the distance recorded for Glabella to the true vertical line different.

To measure how far Glabella is from SN (true vertical line), we first need to establish the patient's natural head position (Fig. 6). To do so, we have the patient stand in front of a mirror. First, the patient is asked to close his eyes and bob his head up and down three times.
After this is complete, the patient is asked to open his eyes and look himself directly in the eyes in the mirror. After we have established the natural head position, we then use the measurement gauge. Our goal is to make sure the leveling bubble is in the lines. This will allow us to take a measurement from the true vertical line to Glabella.

Keep in mind that everybody's head position is a bit different. The further that Glabella is from the true vertical line will affect how we look at the lower third of the face.

Now we need to establish the axis-horizontal plane (Fig. 7). First, we establish the horizontal position using the ear bow. We'll use the pointer on the ear bow to make a mark on the nose when the bow is level.

We have previously established, through axio-path tracing, the hinge axis position on the patient's right and left sides. In combining the horizontal point with the two axis points, the axis-horizontal plane can be established. The axis-horizontal plane is then transferred to the articulator. This allows us to orientate the CBCT data with the articulator mounting.

Now we have the true axis-horizontal plane and the true vertical line combined, and now facial, skeletal and functional issues can be assessed.

In the example we are using, the patient has a mandible that has an architecture problem, which causes her to occlude only on the molars with an anterior open bite.

This is precisely the kind of case where you should be looking for degenerative joint disease. All of the above enables us to establish the parameters and coordinates we need to analyze the face and occlusion and then apply the correct treatment so the patient will have a functioning stable occlusion with the necessary facial improvements.

**Soft-tissue analysis**

The treatment objectives are based on the soft tissue. You perform the surgical treatment objective in this order.

1) Establish the position of the upper lip to the true vertical line in a vertical and horizontal manner.

2) Determine what you need to do with the anterior teeth to create the correct upper lip position.

3) Once you established the anterior part of the maxilla, then proceed to the posterior part of the maxilla and determine if you need to do an intrusion or extrusion of the posterior segments to level the occlusal plane.

In most cases where there's a retrusive chin and a skeletal open-bite, the patient has an occlusal plane, measured from the true vertical line that is somewhere between 102 and 108 degrees. By leveling the occlusal plane, based on the anterior tooth position, you can set the mandible to the maxilla. This will usually balance the lower third of the face. If you still find the chin is too
far forward or too far back, you may need to do genioplasty.

In the example case (Fig. 8), we have performed a surgical treatment objective, established the true vertical line and we have our axis-horizontal plane. In this patient, we need to move the anterior teeth up because in the frontal analysis the patient showed too much tooth structure and too much gingival tissue. To fix this, we balance the maxillary anterior teeth based on the upper lip position.

Once we’ve established the correct tooth position in the anterior, we’re able to set up our occlusal plane at 95 degrees, showing us what we need to do with the posterior segment. In the example case, we need to extrude the posterior segment.

Figure 9 shows how we’ve completed the extrusion of the maxillary segment, and we’ve balanced the occlusal plane. The next objective is to place the mandible with the correct overbite. This is not 2 mm but 4 mm. This is because you want to have an adequate overbite to create adequate disclusion. In establishing the mandible, you can see in our example how the lower part of the face is placed normally enough with the true vertical line (Fig. 10).

In establishing the surgical treatment objective, we see that we want to place the anterior section in the superior direction and the posterior in the inferior direction. These are all the measurements we need to establish a surgical setup. Hopefully, this is performed pre-treatment so the patient has a good idea of what needs to be done.

**Pre-surgical and surgical setups**

The pre-surgical and surgical setups are techniques that do require the clinician’s time. It’s not something that can be outsourced to a lab. You need to spend the time in doing these setups to determine if it’s something that can be treated. Remember, there are cases where you cannot achieve the goals.

Before we get to the setup, it’s worth examining the three basic concepts that this whole system is based on. That’s not just orthognathic surgery, but orthodontics itself.

**Concept No. 1:**
*You need to start with a seated condylar position.*

This is foreign to what we’re taught in the orthodontic profession. We’re trained that when we finish a case we have the patient bite down, and we say that the occlusion looks good or it doesn’t. However, you need to understand that this is a learned muscle position. It’s not a position that is usually conducive to normal joint function.

**Concept No. 2:**
*You can’t believe what you see in the mouth.*

This is where orthognathic surgery comes into play. Don’t try to fix skeletal aberrations with orthodontic tooth movements. Too often cases are treated with a compromised treatment plan, but due to the skeletal dysplasias it is impossible to establish a functioning occlusion, thus resulting in failure.

We need a ruler to measure how we come up with a diagnosis and then we need the same ruler to measure our successes. So in the sample case, the ruler consists of five goals: joints, face, perio, teeth and function.
In a pre-surgical diagnostic setup, the case can be diagnosed and treated before you start. This way you have the result in mind before beginning [five goals]. The orthodontic, surgical and restorative modalities can all be combined pre-treatment. This way the patient knows what is needed to solve his or her particular malocclusion.

These pre-treatment setups are based on the VTO (tooth movement) and the STO (skeletal movement). Once all treatment modalities have been tried, the clinician will know if orthognathic surgery will work for the patient.

The surgical setup is performed just before surgery to determine the skeletal changes needed to correct the skeletal malocclusion and see if the prediction setup is correct. We use our ruler again to make certain that the five goals are obtainable. The surgical splint can also be constructed from the surgical setup. The surgical splint is used to place the skeletal parts in their correct position.

**Steps in pre-surgical setups**

First, we need to get the maxilla positioned in the articulator. We still recommend that you use the articulator as a tool to do your setup. Virtual setups tend not to include the patient's true functioning hinge axis. If you don't have the axis, you're liable to setup an arc of closure that distracts the condyle.

We establish the functioning terminal hinge access of the patient on both the left and right. We're then transferring the hinge access to the side of the face. Once we have it on the side of the face, we can do our axis-horizontal transfer. The dot shows the functioning hinge axis on the patient, represented on both the right and left sides.

The axio-path tracing that we created while trying to find the terminal hinge axis of this patient allowed us to look at the angle of eminence. What we like to see is a steep angle of eminence as that helps disclude the posterior teeth in lateral border movements. Moreover, we like to see nice, smooth curved lines in the jaw motion, as that tells us the condyle and disc are working in harmony with each other.

We determine the best centric relation position in the mouth. Nevertheless, remember, you can't believe what you see in the mouth. That means this may even be worse, especially when we do a true hinges-axis mounting.

Figure 11 shows a true hinges-axis mounting. We have the true hinge axis, we have the axis-horizontal plane and we have the teeth position according to this setup. That means the pin, which was removed for the photograph, would be the true vertical line. The articulator mounting is now the same as the CBCT imaging.

What we see in the next image is that this patient only hits on the left side. Nothing touches on the right. As you can also see, the open bite is even worse on hinge-axis mounted models (Fig. 12)

**Diagnostic setup**

The diagnostic setup we've been discussing is based on the VTO, STO and the articulated cast mounting. The orthodontic setup, as well as a surgical setup, can be done on the same set of hinge-axis mounted models. We can also include in the diagnostic setup the correct arch form so a mutually protected occlusion can be obtained (Fig. 13).

**Surgical setup**

The surgical setup allows us to plan the surgery case before we go to the operating room. We perform this after we've finished the pre-surgical orthodontics and we're getting ready for the surgery itself.
What you should find when you compare the pre-treatment setup with the surgical setup is that the bony part should look very similar on the articulated mounting as the pre-treatment.

In this case, we've leveled the occlusal plane as part of our surgical setup. In doing so, we gained a large correction of the mandible without doing genioplasty. Again, this is based on the axis horizontal and the true vertical line.

Now that the surgical orthodontics has been completed, and the patient is now ready for surgery, we go back and do the natural head position and measure how far Glabella is from SN. We then do our axis transfer and place the markers. Then we double check that we have the natural head position (Fig. 14).

Next, we do our axis transfer, placing the maxilla exactly how it's related to the axis-horizontal plane. This is important because it enables us to place the maxilla on the articulator exactly as it exists on the patient, to the functioning axis.

Figure 15 shows the surgical models mounted according to the axis-horizontal plane. We use a centric bite to position the mandible to the maxilla, allowing the musculature to seat the condyles up and forward.

We then get into our surgical correction. We've corrected the maxilla. To maintain the proper torque of the anterior teeth, we'll need a four-part maxilla. Now we have our anterior segment (lateral to lateral) and two posterior segments (cusp to second molar) and the palates. The anterior segment is positioned vertically and horizontally to the maxillary relaxed lip position. In addition, we take into account the tooth and gingival display the patient exhibits.

We've done the correction in the maxilla, putting the uncorrected mandible on. This shows the discrepancy you see once you've leveled the maxillary occlusal plane. Now we position the mandible. If we've done our pre-treatment surgical orthodontics correctly, things should fit together. Thus, after the mandibular correction is completed in the setup, an uncorrected maxilla is placed on the articulator. You should see a large posterior open bite.

This is also an easy way to construct our intermediate surgical splint, which you can see in Figures 16a & b. Note how we changed the plane of the mandible. This is based on doing the mandible first. By placing the mandible correctly in all three planes of space, we can establish the functional axis of the mandible.

This helps eliminate some of the errors that occur in orthognathic surgery. If we do the mandible first, and we know the vertical measurement that we need, it's easy to place the maxilla correctly to the mandible.

There are certain surgical techniques that need to be applied to accomplish the surgical corrections. By following the proper surgical techniques, the postsurgical relapse can be kept to a minimum.

The other thing that we can do is establish even centric stops, according to the axis position. That's why in Figures 17a & b the models are painted red. We can do an occlusal analysis and equilibration and establish a stable tooth fit before surgery; all of which is based on the true terminal hinge axis.

We're able to get a Class I and we're able to gain enough overbite. We will need to do some post-surgical orthodontics to finish the occlusion, but the image shows the hinge axis closer on the articulator.

If you were able to hold the model, you would notice that there's no rocking. Everything is stable.
You don’t want the patient to come out of burger and find that the patient has trouble finding a stable maximal intercuspation with the joint seated.

In order to gain even stops, we had to remove some tooth enamel around the upper and lower arches. That’s what we do in the operating room before we begin the operation. We do the equilibration when the patient is asleep and before the operation begins.

As you can see in the post treatment intra-oral and extra-oral photos (Fig. 18), the facial changes include a shortening of the lower facial third. An adequate overbite has been established so a mutually protected occlusion can seen. The proper disclusion, where the back teeth separate by at least 2 to 3 mm, has been established.

If we apply the second concept ("you can’t believe what you see in the mouth"), we need to go to post treatment hinge-axis mounted models. Figure 19 shows the cone-beam data, both pre- and post treatment. Note the double plates on the mandible to establish a stable platform to position the maxilla.

_**Surgery**_

One of the most important take-away lessons from this article is that you need to know your surgeon. Establishing a one-on-one relationship with your surgeon can be challenging. If the orthodontist does not know what the surgeon goes through, then in the planning stage pre-treatment, the teeth may be placed in a position that the surgeon will have trouble establishing in the correct skeletal position. This is a relationship that simply takes time.

Once you have knowledge of the surgeon, then you need to know what happens at the hospital because this becomes an important part, especially during recovery.

The people who are handling recovery need an exceptional level of compassion, and they need to be able to handle emergencies. Oftentimes the patient will get sick, and his or her teeth are held together with elastic and wires. The healing period normally lasts ten weeks. It may be longer depending on how the segments are healing. The point is that we don’t get into post-surgical orthodontics before the segments have stabilized.

_**Additional considerations**_

We know that you need to know the joint status. You’ll need to know how to do a soft-tissue analysis and how to establish a surgical treatment objective. You’ll need to know how to do pre-treatment setups and surgical setups. You need to apply all of these techniques on all patients (mixed dentition, adolescent or adult).

If the teeth aren’t in the correct position in the jaw, then there’s no way the surgeon can place the parts correctly, resulting in surgical failure. Most surgical failures happen because of orthodontics.

One of the things you need to keep in mind in your pre-treatment surgical orthodontics is that you established the correct arch form. Without the correct arch form, it’s difficult to put the parts together.

The other thing to keep in mind is the actual 3-D position of the teeth. If you have up-righted...
the upper anterior teeth, the surgeon will have a
difficult time fitting the mandible to this.

If you have tipped the lower anterior teeth back
too far—such as in a Class III—then you cannot
obtain a good maximum intercuspation because of
the incorrect torque of the anteriors. The setup part
of the procedure will give you this information.

_Age_

If it’s an adolescent patient, you can do the
presurgical orthodontic and establish the correct
axial position of the teeth in each jaw. However,
do not try to fix the occlusion. That means the teeth
will be in the proper positions when you approach
the surgery.

As a rule, I won’t get into a surgical case before
a female is in her early 20s, and with males in their
mid 20s. I’ve seen cases where they were done
earlier and actually grew out of the correction.

_Learning these techniques_

We all need to be taught to do these things, and
it needs to be from someone who has done them for
a number of years so you can be certain that the
methods you are learning will work. They are taught in the Advanced Education in Orthodontics (AEO)
course, and we do practice them.

That includes surgical setup, orthodontic setup,
soft-tissue cephalometric analysis and surgical
treatment objective. They need to be practiced a
number of times. It’s not something you can learn
on your own. You need a mentor who will teach you
all the characteristics you’ll need.

In the lab phase of the AEO class, we do get into
mounting cases on the true hinge axis. You will
learn how to establish these on patients. They are
not time consuming. Normally, establishing a hinge
axis in the axio-path tracing and transfer takes no
more than six or seven minutes, so the clinician is not
using a lot of his or her time to establish a correct
hinge-axis mounting.

The instructors will demonstrate how it’s done,
and then have you perform the procedures. Under
the proper guidance, you can learn these techniques
and apply them in an office setting in an economi-
cal manner.

Without the coaching, these procedures can
feel like too much of a chore. Moreover, without
coaching, there’s no way to do a surgical workup
for the benefit of the patient, which of course, is
the main reason you need to know these
procedures.

It also helps if you work with the surgeon
and the restorative dentist because it’s the
restorative dentist who obtains the final out-
come, and he or she needs to finish the case
from where you left it.

It takes some time and it takes some effort
to learn these protocols. But once you do
learn them, and you have the technique, your sur-
gical cases will be more stable, and you’ll cut down
the instances of surgical relapse that you see.

Above all, remember this is all for the benefit
of the patient. You need to spend time learning and
you need to spend time in the operating room to
know the problems the surgeon encounters. Then
you need to spend time in the diagnoses and
workup.

However, the benefit is for the patient, who winds
up with a functioning occlusion and improved face,
and the gingival tissues are healthy and the jaw
functions correctly.

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