PART II

A THORACOLUMBO-SACRAL-ORTHOsis FOR IDIOPATHIC SCOLIOSIS

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Introduction

The “Gillette” style thoraco-lumbo-sacral orthosis is designed for the treatment of certain spine deformities in skeletally immature patients. In this booklet, we will discuss in detail the steps involved in providing this orthosis.

Interpreting the X-ray

Providing an effective spinal orthosis begins with the prescription. Ideally, this is arrived at in a clinical setting. The orthopedist, orthotist and therapist examine the patient and the x rays and discuss the treatment. It is beneficial for the orthotist to be able to see and understand the patient’s x rays. This will help him understand the problem before he begins his task. Later, seeing the x rays taken of the patient in the orthosis will help the orthotist evaluate and improve his technique.

With this in mind, let us examine and interpret a set of x rays. (Figure 1) is the A-P x ray of an 11 year, 9 month old child. The x ray reveals a 25 degree left lumbar curve with the apex or horizontal vertebra at the L1-L2 disc. A compensating right thoracic curve of lesser magnitude occurs above. Next, observe the alignment. The entire vertebral column between T10 and L4, lies to the left of the centerline. The vertebral column above T8 is well centered over the sacrum. The position of the pedicle rings on the x ray indicate a grade one rotation in the vicinity of the apex of the curve. This corresponds with a left lumbar prominence of one point five centimeters measured on the patient. The left side bending film (Figure 2) indicates that the left lumbar curve can unbend to minus five degrees. This gives an impression of flexibility. However, it is even more important to view the right side bending film (Figure 3), because to correct this curve, the lumbar vertebrae must be pushed to the right. The right side bending film reveals that the center of the bodies of “L” three, “L” four, and “L” five do not even reach the reference center line on right side bending. The entire M-L mobility range-of-motion of the lower lumbar vertebrae is to the left of center (Figure 4). It will be difficult to push these vertebrae back into alignment. The right side bending film also indicates that the compensating right thoracic curve
is very flexible as we would expect.

Finally, the A-P film (Figure 4) shows that the pelvis is level. The A-P x-ray is surprisingly reliable as an indicator of leg length discrepancy. Discrepancies greater than one centimeter should be compensated by a shoe heel elevation for the duration of orthotic treatment.

The lateral standing x-ray (Figure 5) reveals a lumbar lordosis of sixty degrees which is probably within the range of normalcy. The thoracic kyphosis, at forty-five degrees, is at the upper limit of what we would consider normal.

This x-ray information is important to the orthotist during all phases of fabrication of the orthosis. The order form should contain data on the location, size and flexibility of each curve. It should also indicate size of thoracic kyphosis and amount of pelvic obliquity. It is also helpful to have a rough facsimile of the A-P spine alignment on the order. See (Figure 6).

Graph of lateral spine deviation

Now that we've completed the interpretation of the patient's x-rays, we must define what must be accomplished for the patient. The lumbar vertebrae must be pushed to the right toward their proper position on the center line. The good alignment of the upper thorax over the pelvis should be preserved. The rotational component of the deformity, and the Cobb Angle should be reduced. If these short range goals are met, we expect the progression of our patient's curve to halt.
These short range goals can be met if:
1. An effective left lumbar holding force is generated by the orthosis.
2. A proper configuration is provided about the pelvis and hips to stabilize the orthosis.
3. An appropriate treatment program is prescribed including exercises.

4. The clinic team sees the patient frequently to maintain and support all aspects of the treatment program.
5. The patient is willing to cooperate.

At the end of this presentation, we will examine the immediate results as indicated by the first x rays in the spinal orthosis.

**Patient Orientation**

After the clinic team has formulated the prescription and the physician has discussed the treatment program with the patient and parents, the patient is shown a sample of what he or she will be receiving. At Gillette, we have found that questions in reference to the patient’s treatment program will have to be answered several times, so it is important that the orthotist be very familiar with the entire treatment program.

The contact which the orthotist has with the patient and parents is quite extensive and somewhat intimate. This is especially true at the beginning of treatment. At that point, most patients feel frightened and vulnerable. How the patient accepts the treatment program will depend to a great extent on how the clinic team members manage to show interest in the individual patient and respect for his or her privacy and feelings.

It is important to thoroughly inform the patient of what he or she will be experiencing during the measuring and modeling procedures. Be specific about provisions for their modesty. Be friendly, not pushy, and respect their state of mind. It is sometimes helpful to refer the abnormally apprehensive patient to a social worker with skills in dealing with emotional problems.

At Gillette, we find it helpful for the therapist to introduce the patient to the exercise program before the orthotist obtains the measurements and plaster impression. It is particularly useful for the patient to know how to do a pelvic tilt.

**Measurements**

After the patient has been thoroughly oriented, begin the preparations for obtaining the measurements and plaster impression.

The patient is given two pieces of snugly fitting cotton stockinette. A pair of holes are cut near one end of each piece for the arms to slip through. The patient dons the privacy. Underclothing need not be removed. A family member or nurse helps him or her into the stockinette.
Plaster Impression

The plaster impression is the most critical step in obtaining a proper positive model. It is important to keep in mind that the pelvic shell which will be generated from the positive model should have the following characteristics:

One, it should hold the lumbar spine in relative flexion.

Two, it should be contoured to look into the pelvis to resist rotation.

Three, the waistline contour must resist superior migration of the orthosis.

Four, it should provide room for the spine and para-sacral musculature to move into a position of better alignment.

and Five, it must be comfortable.

When the measurements have been completed, a five centimeter wide, point five centimeter thick strip of felt is inserted between the two layers of stockinette. The strip should be on the anterior or posterior midline and extend the full expected length of the impression. Inform the patient that the felt strip will give protection when the impression is removed with a cast cutter. Explain that the cast cutter blade vibrates rather than spinning. Demonstrate its safety on the palm of your hand.

Before plaster application is begun, the patient is positioned in a comfortable, well aligned posture. A simple, adjustable frame will help facilitate this (Figure 7). The patient’s forearms rest on adjustable horizontal bars. If necessary, the pelvis is now leveled by placing the appropriate spacing under the patient’s foot on the low side. The feet and legs are positioned and aligned symmetrically so that a third horizontal bar just touches the posterior calf of each leg.

Next, the waistline is emphasized by applying two pieces of tape as shown in (Figure 6). The first piece of tape defines the waist contour on the side of the curve convexity. It pulls medially and slightly inferiorly toward the frame on the right side of the patient. The rightward pull of this tape is balanced by the second piece of tape which is pulling towards the left, defining the right waistline.

Prior to applying the plaster wrap, the assis, the iliac crests, the rib margin, the greater trochanters, and the superior border of the pubis are marked with indelible pencil, and several measurements are made.
Snug circumference measurements are made at the waist and at the hips just proximal to the greater trochanters (Figure 9). The distance between the anterior-superior iliac spines is measured (Figure 10).

(Figure 9)

(Figure 10)

The patient now assumes a position of reduced lumbar lordosis. Flexing at the hips and knees about twenty degrees will make it easier for the patient to achieve this position. Frequently, patients are unable to hold a full pelvic tilt until the plaster sets. In such cases, gentle but firm pressure is applied anteriorly against the abdomen and medial aspect of the ilium and posteriorly against the lower buttocks.

Attention must also be given to medio-lateral alignment. The mid-thorax should be centered over the pelvis. The impression should be well molded just medial to the anterior portion of the iliac crests so that these very important bony features become well defined. Since all of these tasks cannot be accomplished simultaneously, advantage is taken of the moldability of the plaster in the early stages of setting.

As soon as the plaster wrap becomes rigid, cut lengthwise over the strip of felt with a cast cutter. A scissors is used to cut the outer layer of stockinette (Figure 11). The impression is now removed from the patient. The inner layer of stockinette remains on the patient. The impression shell is closed and patched immediately while it is still somewhat flexible.

Later, in the plaster room, the indelible markings on the inside of the impression are emphasized. The shell is then filled with a mixture containing approximately equal volumes of molding plaster and polystyrene foam beads.
Modifying the positive plaster model

Modifications of the plaster positive is still a combination of art and orthotic principles. We hope the following suggestions will help guide the orthotist to a more consistent result.

A few reference lines will help the orthotist visualize the symmetry and alignment of the model. The reference lines can easily be established by wedging up the left or right side of the model so that the waist grooves are level. A horizontal line is then drawn across the abdomen of the model through the axis's. Find the center of the horizontal line between the axis's, and then draw a vertical line through that point. This becomes the anterior vertical pelvic center line (Figure 12). A center point and vertical reference should be located on the posterior surface of the model in a similar manner.

(FIGURE 12)

Next, examine the medio-lateral alignment of the thorax with respect to the pelvic centerline. It may be necessary to shave plaster off one side of the thoracic section and add plaster on the opposite side to correct the misalignment. Corrections of this nature should be blended in to create a symmetrical relationship between the two posterior-lateral thoracic surfaces.

Proceeding with the plaster removal portion of the model modification, the waistline indentation created by the pull of the tape must be exaggerated to a depth of about two to three centimeters. This will be the depth just anterior to the lateral midline. As the waist groove proceeds anteriorly, it should plunge downward, staying close to the medial aspect of the anterior iliac crests and the anterior-superior iliac spines. Proceeding posteriorly, it should level off and disappear about four centimeters posterior of the lateral midline (Figure 13).

(FIGURE 13)

Plaster is removed from the abdominal area to create a maximum pressure region about six centimeters above the level of the axis's. Inferiorly, the abdominal outaway should slope gently anteriorly to prevent pressure on the pubic area (Figure 14).
Superiorly, the abdominal cutaway should slope away from the body more sharply to avoid pressure on the ribs (Figure 15). When the model is viewed from the side, you should see a minimum A-P diameter located about six centimeters above the level of the axis’s knees flexed twenty degrees (Figure 16). We recommend that the orthotist make such an observation (and notes) when obtaining measurements.

(FIGURE 14)

The depth of the abdominal plaster removal will vary depending on the patient’s body type, and is still a matter of subjective judgement. In most cases, the orthotist should be trying to achieve an anterior abdominal contour very similar to what he would observe if the patient were lying supine with hips and buttocks down and a slight rolled pad placed under the lower abdominal area. (Figure 17). This is a simple procedure of creating a roughly vertical flat on the buttocks inferior from about the axis level (Figure 17). The flat is then blended gently into the intersecting contours.

(FIGURE 15)

(FIGURE 16)

Next, the lower buttock area is skived down two to four centimeters, depending on the fleshiness of the patient. This is a simple procedure of creating a roughly vertical flat on the buttocks inferior from about the axis level (Figure 17). The flat is then blended gently into the intersecting contours.

(FIGURE 17)

(FIGURE 18)
The left lumbar prominence which usually accompanies a left lumbar curve is completely shaved off and the new contour is blended in. About one centimeter is shaved off the model in the area of the left greater trochanter. Plaster is added just anterior and inferior to the greater trochanter to create a flattened area (Figure 18).

Finally, plaster is removed from the lateral and posterolateral aspect of the right hip. Laterally, the depth of this plaster removal is 0.5 to 1.0 centimeter (Figure 19) depending on the thickness of the subcutaneous tissue. Postero-laterally, 1.0 to 1.5 centimeters of plaster may be removed. This plaster removal should not approach closer than 1.5 centimeters to the iliac crest. It may, however, approach the very outline of the greater trochanter.

(FIGURE 19)

Any one of several materials may be utilized to build a plaster positive creating an area of pressure relief. It is the habit at Gillette to use folded plaster points for the basic build up and blend these in with plaster.

The most obvious areas requiring relief are the anterior-superior iliac spines and iliac crests. Depending on prominence, 5 to 10 centimeters of build-up is added to the antero-lateral and lateral aspects of these locations precisely marked on the model. Plaster reliefs are made antero-laterally and laterally because this is the future location of these prominences as the patient grows. When creating these reliefs for bony areas, it is extremely important to keep in mind that the flesh tends to ride about 1.5 centimeters higher on the body. Therefore, the reliefs should be extended a similar distance inferior to the markings on the model.

Next, the lumbar concavity on the concave side of the lumbar curve should be adequately filled in (Figure 20). Fullness is created in this area to provide room for the lumbar spine and paraspinal musculature to move into as a corrective alignment is achieved in the orthosis. This plaster addition to the lumbar concavity should be carried laterally to include some plaster addition in the waist groove and to the inferior rib margin. The result of plaster removal on the convex side and plaster addition on the concave side is a reversal of the pathological asymmetry in the lumbar area.

(FIGURE 20)

Finally, about one centimeter of plaster should be added to the lateral and anterior rib margins to create a proper flare above the waist indent (Figure 21).

As modifications are made the model is frequently measured and checked against the measurement on the form (Figure 22).

When modifications are complete and the surface is made smooth, it is ready to be used as a pattern in the formation of the basic shell of the orthosis.
Fabrication

A great deal of time and care have been invested to generate this precise pattern for the pelvic section shell. The shell itself should retain its configuration in the face of stress and time. It must also be flexible enough to open and close for donning and doffing. We have found polypropylene to be a suitable material from the standpoint of both formability and service. The drape-vacuum-assist method of generating a plastic shell is used at Gillette and is well known in the field of orthotics.

A 0.5 centimeter thick sheet of polypropylene of appropriate size is placed on a metal sheet covered with a 0.003 inch thick teflon coated fiberglass fabric (Figure 23). These are then placed in the oven at four hundred degrees fahrenheit for approximately fifteen minutes. The polypropylene turns transparent when it is sufficiently hot. The polypropylene and fiberglass sheet are then removed from the oven, turned upside down, and lowered onto the model. The fiberglass sheet is peeled away, and the hot polypropylene is wrapped around and sealed against itself along the posterior midline and inferior end of the model. Also, it is sealed around the vacuum pipe at the superior end of the model.

As the hot polypropylene cools on the cold model, large tensile stresses are generated in the material, and it sometimes cracks. Approximately five minutes after covering, while the polypropylene is still hot and easy to cut, a cast cutter (Figure 24) is used to deeply score the plastic around each end and along each side of the seam, running up the posterior midline. The deep scoring helps to confine the cracking to desired locations. When the shell is completely cooled to room temperature, it is cut from
the model. Approximate but generous trim lines are established, and the shell is trimmed on a sole cutter (Figure 25).

Installing the three metal reinforcement bars is a straightforward procedure. The two paraspinal reinforcement bars may be either stainless steel or aluminum. Each paraspinal bar should be attached near the inferior end and three centimeters inferior to the waist groove (Figure 26). This leaves the superior portion of these bars free, in case they must be adjusted. The semi-circumferential waist bar is the most important of the three bars and should be steel. The waist bar should be contoured to fit neatly into the waist groove laterally (Figure 27). The semi-circumferential bar should be fixed in place with screws if possible so that it may be readily removed for A-P diameter adjustment.

Velcro pile is cemented to the inside of the shell where the lumbar pad will be located. The exact position, configuration, and size of the lumbar pad will be determined during fitting.
Two closure straps are needed. The lower closure strap should be located within two centimeters of the bottom of the orthosis. The upper closure strap should be located at about the level of the waist groove.

Fitting

Fitting the orthosis provides the orthotist with a second opportunity to gain the confidence and respect of both patient and parents. Be deliberate and efficient in performing the fitting. Always inform the patient what will happen next and respect the patient's privacy and modesty. Listen attentively and respond when they describe any discomfort. It is very important to reassure the patient that within a few days he or she will be physically comfortable in the orthosis.

The location of inferior trim lines are established with the patient seated erect. Anteriorly, the shell should just lightly impinge on the rectus femoris bilaterally (Figure 28). The posterior-inferior edge of the shell should clear a hard chair by two centimeters. (Figure 29). Laterally on the concave side, the inferior border of the orthosis should pass across the gluteus medius just superior to the greater trochanter. On the convex side, the anterior edge of the trochanteric extension must be trimmed back far enough so that it doesn’t seriously interfere with the lateral thigh when the hip is flexed (Figure 30).

When the reinforcing hardware and straps have been applied, the orthosis is ready for fitting.

(FIGURE 28)

(FIGURE 29)

(FIGURE 30)

The anterior and lateral portions of the superior border of the orthosis should not impinge uncomfortably on the ribs (Figure 31).
The paraspinal thoracic extension should be in firm contact with the posterior thoracic below the inferior angle of the scapula (Figure 32). There should be evidence of considerable compression of the lower buttocks. These two forces working together with abdominal compression passively reduce lumbar lordosis.

![Figure 33](image_url)

Whenever possible, the x rays should be available to the orthotist at the time of fitting. The x rays help give the orthotist a very precise picture of the deformity. The x-ray will show the exact shape that the lumbar pad should be in order to fit into place between the eleventh rib and the iliac crest. Remember, however, that the x-ray image is about 25% larger than the actual anatomy (Figure 33).

![Figure 34](image_url)

The transverse cross-section shape of the lumbar pad should show a flat section medially which slopes up to a rounded crest. The thickness of the pad should gradually reduce to nothing lateral to the crest. The flat section pushes anteriorly to derotate the scoliotic spine. The crest of the pad tucks into just lateral to the paraspinal muscles and pushes medially (Figure 34). If the lumbar pad is placed too medial or if the A-P diameter of the shell is too large, the
There should be no pressure exerted by the orthosis in the right lumbar area. If the apex of the patient's curve is in the "T"-twelve..."L" one area (Figure 36), he or she will benefit from a small, very low thoracic pad installed on the same side as the lumbar pad (Figure 37). This pad should be only about six centimeters top to bottom. Every effort should be made to place it as low as possible so it just exerts pressure on ribs eleven, ten and perhaps nine. This pad should have a lateral placement so that the force it exerts will be towards the midline only. It should not be positioned posterolaterally where it will push somewhat anteriorly. The posterior attachment strap should be looped around the medial border of the thoraco extension and anchored on the left paraspinous baffle. The anterior end of the attachment strap can be slipped through a slot in the abdominal apron, and attached to the anterior surface of the apron. The location of the anchor points are best determined with the orthosis on the patient.

The trochanteric extension must sometimes be adjusted to properly stabilize the orthosis. From a position behind the patient, examine the vertical alignment of the orthosis. If the top of the orthosis is tipped to the right, the trochanter extension is too tight and should be bulged and flared out. This rarely happens. It is more common for the top of the orthosis to be tipped to the left or toward the convexity of the lumbar curve (Figure 38). Padding must then be added to the inside surface of the trochanteric extension to achieve better alignment. If the inferior closure strap is located too superior, this also can cause the right side of the orthosis to be tilted medially at the top (Figure 39).
Evaluation

When the humerus is viewed with the top of the humerus and the olecranon process, it may be obscured. (Figs. 1 and 2 in the reference.) The humerus is exposed by removing the triceps and the olecranon process. The humerus is then manually rotated to the desired position. The humerus is then fixed in the desired position using a variety of techniques. (Fig. 3 and 4 in the reference.)

The humerus is then fixed in the desired position using a variety of techniques. (Fig. 3 and 4 in the reference.)
The most common sites for skin problems are the ischium, the greater trochanter, and the lumbar pad area. Any problems at the ischium can usually be dealt with by heating and bulging out the shell. Pressure problems at the other two locations are not so simple, because both pressures should be maintained at the maximum tolerable level. The type of skin irritation at the trochanter is usually due to abrasive action as the patient walks. This can be alleviated by contouring and by padding that area with anti-shear foam rubber.

The lumbar pad must be carefully shaped and the thickness managed so that after an hour of wear the skin shows a definite blush covering the pad location. The blush should disappear in about fifteen minutes. The total lumbar pad pressure can be increased by removing the semi-circumferential waist bar and bending it to decrease the A-P distance.

**Evaluation**

When the orthotist is satisfied with the fit of the orthosis and the patient is comfortable, x-rays must be taken of the patient in the new orthosis. Again, it is extremely valuable for the entire orthopedic team to meet together, they can see the patient, the orthosis, and the new x-rays to evaluate the results achieved.

Now let's return to the patient we viewed earlier. These are her x-rays in the orthosis (Figure 40). The opaque markers in the lumbar pad indicate that it is well centered between the twelfth rib and the iliac crest. The two markers shown here bracket the crest of the pad.

Leftward misalignment of the spine has been reduced significantly at all levels between T7 and L1. Alignment of the vertebral elements above T1 remains excellent. The Cobb Angle of the lumbar scoliosis curve has been reduced from twenty-five degrees to twelve degrees. Vertebral rotation has been reduced. A check of the lateral x-rays reveals

(FIGURE 40)
that the thoracic kyphosis has been reduced from forty-five degrees to thirty degrees. So far, the orthosis appears to be successful.

Before sending the patient home, the team or one of its members should stress the importance of exercises and review with the patient and parents skin care and the wearing schedule of the orthosis. They should be instructed to wash the orthosis every three days. The closure straps should be marked, indicating the proper tightness, and the patient instructed to push the orthosis firmly down against the iliac crests while donning it (Figure 41). Carefully donning the orthosis as low as possible will reduce the chances of it riding up and impinging painfully on the ribs.

Finally, be sure that patient and parents realize that the orthotist should be called immediately if any problems develop with the new TLS-Orthosis.