Surgical Technique

Luque™ Segmental Spinal Instrumentation
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Introduction

Scoliosis correction is limited by the amount of soft tissue and osseous deformities prevalent in the spine.

Soft tissue deformities include all of the ligaments on the concave side of the spine which involve verte-ebra to vertebra, vertebra to pelvis, and vertebra to the thoracic cage; as well as all of the paravertebral muscles and adjacent soft tissue structures.

Bony deformities in the posterior vertebral elements consist of an elongation of the convex side and a shortening of the concave side (Fig. 1). To this can be added the rotational effect which alters the normal alignment of the articular facets.

The premise of Luque S.S.I. (Segmental Spinal Instrumentation) is that if the soft tissue deformities are released from the concave side of the spine, and if the bony deformities are removed from the convex side of the spine, the extent of the final correction will depend upon the elasticity of the intervertebral discs and ligaments.

Preoperative Management

After routine preoperative examinations, it is imperative to obtain a preoperative x ray of the spine showing maximum preoperative correction, i.e. by lateral bend, casting, bracing, physiotherapy, Cotrel traction, halo femoral traction, etc. No scoliotic deformity should be corrected with Segmental Spinal Instrumentation by more than 10° beyond the best preoperative x ray. If this x ray is taken with the patient under a tolerable stress and without anesthesia, the chances of neurological complications are reduced to a minimum. Programmed correction of the scoliotic deformity with well balanced curves can then be planned preoperatively.

Based on the preoperative maximum-correction film, a flexible rod, pin, or wire is bent so as to provide for 10° additional correction, but always maintaining a well-balanced spine. This flexible rod is used as a model for contouring the Luque Rods for surgery using a Spinal Rod Bender (1292-99). By using this method of prebending rods, it is possible to predict the spinal balance and the amount of correction, while minimizing the possibility of neurological damage during the corrective procedure.
Surgical Technique

Posterior Approach

A posterior longitudinal incision is made, extending above and below the area of deformity. A complete subperiosteal dissection is carried out with complete exposure of the spinous processes, laminae, articular facets, and transverse processes of all involved vertebrae.

Soft Tissue Release

All muscle and ligament attachments to the various parts of the posterior elements of the spine are released, paying special attention to those on the concave side which form tight reins from vertebra to vertebra and from the spinal column to adjacent structures. The ligamenta flava are carefully detached with a curette to provide for wire passage under the laminae (Fig. 2).

Wire Passage

Preformed wire loops with beaded ends are available in open- or closed-end configurations, 20cm or 30cm lengths, and with wire diameters of 1.0mm or 1.2mm. The larger diameter wires are normally used at the ends of the construct. The looped ends of the double wires are passed under and around the laminae (Fig. 3). Only one double wire is passed at each level. The looped end will be cut later to form two separate wires—one for the rod on the concave side of the spine and one for the rod on the convex side. Wire passage is facilitated if the looped end of the wire is first bent to the shape of the lamina.

Schlein Clamps (8503-785, fine nose and 8503-786, broad nose) are suited for grasping the wire loops and pulling them through the neural canal.
Facetectomies

Using a Rat Tooth Rongeur (Cat. No. 3314), total facetectomies are done bilaterally, forming posterolateral troughs for the subsequent bone graft (Fig. 4). In very severe immobile curves, it may be necessary to perform a closing wedge osteotomy at the apex of the curve on the convex side of the spine. This will avoid stretching the spinal cord during correction. In such cases, part of the lamina and spinous process is removed on the convex side (Fig. 5) and the distance is fixed with a concave rod.

Segmental Correction

Using a curette (3675-00-02) or an awl (533), holes are prepared at the bases of the spinous processes at the upper and lower end of the curve. These holes will serve to anchor the ‘L’ in the Luque Rods to prevent their migration.

Two Luque Rods are then contoured using Rod Bending Tubes (1292-98) to achieve no more than a 10° increased correction beyond the best preoperative x ray. Contouring can be accomplished either before the surgery actually begins or during the procedure itself. One rod is fashioned to be implanted on the concave side of the spine (concave rod), and the other rod is fashioned to be implanted on the convex side of the spine (convex rod).

FIGURE 4—Total bilateral facetectomies, forming posterolateral troughs for subsequent bone grafts

FIGURE 5—Wedge osteotomies may be necessary in very severe immobile curves to avoid stretching the spinal cord during correction
Luque Paravertebral L-Rods (available in both 3/16-inch and 1/4-inch diameters) in which the “L” is already formed are available. If Luque Straight Rods (1292-20) are used,* the superior end of the convex rod and the inferior end of the concave rod are bent in the shape of an “L” for insertion into the holes prepared at the bases of the two spinous processes. Straight rods should not be used because they migrate. Using wire cutters (1322-50), the loop of each double wire is cut to produce two separate wires. At each level, one wire is positioned on the convex lamina while the other wire is positioned on the concave lamina (Fig. 6). These wires will be used later to secure the convex and concave Luque Rods. Double wire should be used on each rod at the proximal and distal vertebrae.

Starting on the convex side of the spine, the “L” bend of the convex rod is placed through the hole in the base of the spinous process at the upper most vertebra to be instrumented. Using a Schlein Clamp (8503-785) or Luque Wire Twister (1292-97), the “L” portion of the rod is secured by twisting the wires at that level around the “L” bend (Fig. 7). The remainder of the convex rod is then secured to the lamina by twisting one wire around the rod at each level, beginning at the top and continuing to the apex of the curve. Wires are loosely applied to the portion of the convex rod inferior to the apex of the curve. These wires will be gradually tightened later (Fig. 8).

NOTE: 1/4-inch Luque Rods are extremely difficult to bend in an “L” shape because of the larger rod diameter. Straight 1/4-inch Luque Rods are available through Specialty Products (1292-21).
Similarly, the concave rod is first secured by wiring its "L" bend into the hole prepared for it at the base of the lower spinous process. Wires are loosely applied to the portion of the concave rod at the apex of the curve (Fig. 9) Using the convex rod as a lever to apply direct pressure over the apex of the curve, the individual wires are carefully tightened on both sides of the spine, producing transverse traction on the concave side. **The wires should be tightened against the rod as it is pushed into the spine rather than tightening the wires as a means of pulling the rod to the spine. Care must be taken not to overtighten the wires to avoid damage to the laminæ.** At the conclusion of this process, the forces of correction are spread over the length of the curve, rather than being concentrated at the upper and lower ends only.

After all the wires have been carefully tightened, the Luque Rods are wired together transversely in two or three places with double loops of wire (Figs. 10 and 11) coupling the rods together securely.

This applies rigid internal fixation of the spine. The concave rod is most stressed at the apex of the curve. This is where the convex rod provides the greatest amount of support. Conversely, the points of greatest stress for the convex rod are at the ends of the curve. These are the points where the concave rod provide greatest support by fitting snugly against the laminæ of the end vertebrae. If stabilization of the sacrum is necessary, it is obtained by bending rods distally and going through the sacroiliac in the way of a sacral bar (Fig. 11). If a greater biomechanical lever is required, the rods can be contoured and inserted through the ilium utilizing the Galveston technique.
Autogenous Bone Graft
All removed spinous processes and facets are used for
the bone graft. If necessary, additional graft material is
obtained from the ilium. The bone graft material is
packed into the paravertebral, posterolateral troughs
produced during the facetectomy.

Closure
Prior to closure, the excess portions of all twisted wires
are cut at about 3/4 inch length, and the cut ends are
tamped down. Closure is accomplished in anatomical
planes.

Postoperative Management
Postoperative casting or bracing is recommended.
Patients are generally walking in 36 hours but are
discouraged from engaging in strenuous activity for
six months.

Luque Segmental Spinal Instrumentation
Ordering Information

<table>
<thead>
<tr>
<th>Cat. No.</th>
<th>Description</th>
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<tbody>
<tr>
<td>533</td>
<td>Awl</td>
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<tr>
<td>1292-01/06</td>
<td>Luque Prebent Rod, 3cm x 20/40/60cm</td>
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<td>1292-10/15</td>
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<td>Spinal Fixation Wire, Closed w/ Beaded Loop</td>
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<td>1292-70/73</td>
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<td>Luque Wire Twister</td>
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<td>Contouring Plunger</td>
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<td>8503-785</td>
<td>Schlein Clamp—Fine Nose</td>
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<td>8503-786</td>
<td>Schlein Clamp—Broad Nose</td>
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Bone Grafting
1. All removed spinous processes and facets are used for grafting.
2. If needed, additional graft material is obtained from the ilium.
3. The graft material is packed into the paravertebral posterolateral troughs prepared during the facetectomy.

Closure
1. Excess twisted wire ends are cut to about 3/4 inch (19mm) and the ends tamped into the bone graft (see PRECAUTIONS).
2. The closure is carried out in anatomical planes.

Postoperative Management
1. Casting or bracing is recommended.
2. Patients are usually permitted to walk 36 hours after the operation.
3. Patients should be advised against strenuous activities for six months postoperatively (see PRECAUTIONS).

CONTRAINDICATIONS
Use of the Luque System is contraindicated where more than 10° correction above the maximum shown on the best preoperative x-ray film is deemed necessary. Because the Luque System does not provide axial distraction, use of the Luque System is contraindicated in burst fractures of the thoracolumbar spine caused by an axial load.

WARNINGS
1. Do not attempt to achieve correction of more than 10° above the maximum shown in the best preoperative x-ray film.
2. Detach the ligamenta flava carefully to avoid neural damage.
3. Exercise care when passing the wire loops through the neural canal at each level in order to prevent damage to the dura mater. Do not force the wire loops into the neural canal. Once the wire loop has been passed under the lamina, it should be pulled, not pushed, the rest of the way through. Tight traction against the anterior side of the lamina will help ensure that the dura is not contacted.
4. Because of possible migration, do not implant straight rods.
5. If a wire breaks due to overtightening, or due to other reasons after the rod is in place, do not attempt to pass another wire. There is increased risk of spinal cord injury if an attempt is made to pass a wire through the lamina with a spinal rod in place.
6. Fragments of bone and disk material compressing the anterior surface of the dural sac should be indirectly reduced posteriorly or directly removed anteriorly.
7. Contouring to match a curve greater than 60° places undue stress on the spinal rods and should be avoided.
8. Do not continue to pass a wire if cortical evoked potential changes during passage.
9. The use of acrylic bone cement with wire has been reported to increase complications; contribute to wire fatigue, and inhibit solid bony fusion.
10. Spinal cord injury has occurred when sublaminar wires were used with a Harrington Distraction Rod.
11. This device is not approved for screw attachment or fixation to the posterior elements (pedicles) of the cervical, thoracic, or lumbar spine.

PRECAUTIONS
1. The preoperative x-ray films on which the planned correction will be based should be taken without the use of anesthesia while the patient is under tolerable stress from lateral bending, traction, or other temporary corrective devices.
2. Place the patient prone on a frame to allow the abdomen to hang free and to aid in preventing problems from intraoperative hemorrhage.
3. Use the appropriate means, such as Bending Tubes or Rod Benders, for contouring and/or bending.
4. Avoid damage to the laminae and wires by not overtightening the wires.
5. Cut off twisted wire ends and tamp them down to avoid wire protrusion once the patient becomes ambulatory.
6. Advise the patient to refrain from strenuous activities for a period of six months following the operation.
7. Never reverse bend a rod. If a rod is bent in one direction at the same point then is bent in the opposite direction, its strength will be markedly reduced.
8. Avoid overcorrection. Since most corrections result in spinal column lengthening, consider effects on vasculature, cord elongation, and respiratory mechanisms.
9. Every effort must be made to precontour rods. Contouring a rod in place places the patient at risk.
10. Sagittal curves must be maintained. Vital capacity is diminished when thoracic kyphosis is flattened. Ambulation will be hampered by loss of lumbar lordosis.
11. Segmental Spinal Instrumentation should be used with great caution in patients with achondroplasia or other conditions in which there is an acquired or developmental narrow spinal canal.
12. A brace should be used to give stability to the collapsing spine.
13. Fusions of the lower spine (T-12 to sacrum) have reported greater failure rates in patients who were not braced postoperatively.

ADVERSE EFFECTS
The following complications and adverse reactions have been reported with the use of Segmental Spinal Instrumentation. These occurrences and the possibility of other complications known by the physician should be discussed with the patient prior to surgery.

Paraplegia (paralysis), complete or incomplete. Delayed onset has occurred even when cortical evoked potential was unaffected during surgery.
If a solid bony fusion mass is not achieved, the spinal rod may break as a result of long-term stresses. Such an occurrence will likely require another surgical procedure to remove the device and, possibly, reinstrumentation.
Dura mater tears leading to cerebrospinal fluid fistula or pseudomeningocele.
Spinal cord injuries due to passage of wire.
Epidural bleeding.
Wire fatigue and device failure may result when the rod is pulled to the spine instead of reducing the spine to the rod.
Rod breakage.
Wire breakage.
Note: Either of the above occurrences may necessitate reoperation to remove and/or replace instrumentation.
Laminar erosion.
Kyphosis occurring at the top of the segment being instrumented, leading to postural deformities, pain, skin breakdown, residual neural compression.
Corrosion at the rod/wire interface contributing to breakage, pseudarthrosis, and sacroiliac joint pain.
Wound infection requiring implant removal.
Pain.
Collapse of fracture site.
Hematoma.
Wound dehiscence.
Prominent wire or rod or both.
In short constructs and in porotic bone wire cutout has occurred.
Urinary tract infection.
Decubitus ulcer.
Deep vein thrombosis, pulmonary embolism.

In addition to the obvious risk that any orthopedic implant may fail, loosen, or fracture, the following risks of adverse tissue responses and possible complications must be explained to and discussed with the patient:
1. A variety of metals, polymers, chemicals, and other materials utilized with orthopedic implants has been known to cause cancer and other adverse body reactions. In addition, any factor that causes chronic damage to tissues may be oncogenic. Cancer can metastasize from soft tissue sites (lung, breast, digestive system, and others) to bone, including areas adjacent to implants, or it can be seeded to these locations during operative and diagnostic procedures (such as biopsies). Paget's disease has been reported to progress to cancer; patients suffering from this disease who are candidates for implantation procedures in the affected areas should be warned accordingly.
2. Implantation of foreign material in tissues can elicit an inflammatory reaction. Recent literature suggests that wear debris (including metal, polyethylene, ceramic, and cement particles) can initiate the process of loosening. While formation of wear debris may be an inevitable consequence of motion at articulating implant surfaces, optimal technique for cementing or fixation of the device should be employed in order to minimize motion that can generate such particles at the bone/prosthesis or cement/prosthesis interface.
3. Metal sensitivity has been reported following exposure to orthopedic implants. The most common sensitizers (nickel, cobalt, and chromium) are present in orthopedic grade stainless steel and cobalt-chrome alloys. Titanium and its alloys (grade 2, 4, and 6) are markedly less allergenic and are recommended for use in persons with a history of allergies or metal sensitivity.
Luque™ Segmental Spinal Instrumentation

Surgical Approach
1. The patient is placed on a frame so that the abdomen hangs free.
2. The posterior incision should extend above and below the deformity.
3. Complete subperitoneal dissection with exposure of the spinous processes, laminae, articular facets, and transverse processes of all involved vertebrae is carried out.
4. During the soft tissue release, all muscle and ligament attachments to the posterior elements of the spine are divided precisely those forming tight connections on the concave side of the curvature.
5. Using a curette, the ligamentous bars are carefully detached to provide for wire passage under the lamina.
6. For each level to be instrumented, a 8.5 mm (25 gauge) stainless steel wire with outside diameters 0.064 inch (1.22 mm) or 0.038 inch (1.0 mm) thickness is cut and looped into a double strand. Closed loop wires may also be used for this double wiring procedure.
7. At each level, the looped end of one strand is carefully passed under and around the lamina, using fine-nose or broad-nose Schanz clamps. The wire loops are passed more easily if they are first bent to the shape of the lamina.
8. To form posteriorly treated for bars bone grafting, facetectomies are carried out with a K. T. Jones retractor.
9. In severe kyphotic curves, a closing wedge osteotomy at the apex of the curve is required on the convex side of the spine may be necessary.
10. To anchor the Luque rods at the upper and lower end of the curve, holes are prepared at the bases of the spinous processes, using a curette or an awl.
11. Use of cortical autogenous potential monitoring during passage of wires and other procedures which have the potential to damage the spinal cord can provide the surgeon with information vital to avoiding spinal cord injury.

Contouring and Bending of Luque Rods
Contouring to achieve more than 10 additional frontal plane correction beyond the coronal plane, the best preoperative 3D VDISK [or MABDISK] can be done before or during surgery. Desired sagittal plane curvature should also be contoured into the rod.

1. Using rod bending tubes (129-99) and a suitable point rod bender (129-99) and Luque shaped Luque rod is contoured to the concave side of the convex side rod (concave rod) and one for the convex side (convex rod) of the spine.
2. To avoid the danger of rod migration when straight Luque rods are used, the upper end of the convex rod and the lower end of the concave rod should be bent into a "L"-shape. This is accomplished using rod bending tubes.

NOTE: Straight Luque Rods 1/8 inch (3 mm) thick are very difficult to bend see PRECAUTIONS. It is recommended that 1/4 inch Luque Rods with prebent 1/8 inch be used. A bending press or suitable rod bender should be used for additional contouring.

PRECAUTIONS: Never reverse bend a rod to correct for "overcontouring." If a rod is bent in one direction then bent the opposite direction at the same point, its strength will be significantly weakened (see WARNING).

Segmental Correction
1. With wire cutters, the loop of each double strand is cut to produce two wire ends.
2. At each level, one wire is positioned on the convex laminae and the other one on the concave laminae for correct alignment of the Luque rods.
3. Starting on the convex side, the "L" part of the convex rod is placed through the perforations in the bone of the spinous process at the upper vertebra involved.
4. The "L" bend is secured using a Schanz clamp or Luque Wire Twister (129-97) to bind the wires around the "L".
5. Beginning at the top and continuing to the apex of the curve, the convex rod is secured to the lamina by twisting one wire around the rod at each level. Ends should be secured with double wires, preferably 1.0 mm diameter.
6. The wires are applied loosely to the convex rod below the apex of the curve. They will be gradually tightened later on.
7. The "L" bend of the concave rod is placed into the perforation prepared at the base of the lower spinous processes and the apex of the convex curve.
8. Wires are loosely applied to the portion of the concave rod at the apex of the curve.
9. The rod and spine should be pushed to desired correction rather than using wire tightening to achieve the correction.
10. The individual wires on each side of the spine are carefully tightened. The concave rod applies direct pressure over the apex of the curve. The concave rod produces translaminar traction.

NOTE: Do not overstretch the wires to avoid wire breakage or damage to the laminae (see PRECAUTIONS).

Extension: If a wire breaks during tightening or any other time after the rod is in place, passing another wire should not be attempted. The risk of spinal cord injury increases if wire passing is attempted when the rod is in place.

11. The Luque Rods are wired together transversely in two or three places, using double wire strands, to increase the stability of the system.

12. When the laminae joint is to be stabilized, the rods are bent distally to form tubular bars which are inserted into channels prepared between the cortices of the lamina. Other methods of fixation to the laminae have been reported to result in higher rates of pseudarthrosis.

INFORMATION FOR USE
Luque Spinal Instrumentation, which is available from the thoraocolumbar spine, including T1 to S1 and is indicated in the correction of the scoliotic deformity resulting from spinal disorders, congenital disorders, atrophic muscular paralysis, spinal cord, or other nerve injuries. The Luque rod has the advantage of additional correction beyond that shown in the preoperative maximum correction film.