Leg lengthening

Leg lengthening involves a variety of surgical procedures used to correct legs of unequal lengths, a condition referred to as limb length discrepancy (LLD). LLD occurs because a leg bone grows more slowly in one leg than on the other leg. Surgical treatment is indicated for discrepancies exceeding 1 in (2.5 cm).

Purpose

Leg lengthening also known as bone lengthening, or correction of unequal bone length, has the goal of correcting LLD and associated deformities while preserving function of muscles and joints. It is performed to:

- Lengthen an abnormally short leg (bone lengthening or femoral lengthening). Leg lengthening is usually recommended for children whose bones are skeletally immature, meaning that they are still growing. The surgery can add up to 6 in (15.2 cm) in length. The leg lengthening and deformity correction process is based on the principle of distraction osteogenesis, meaning that a bone that has been cut during surgery can be gradually distracted (pulled apart), leading to new bone formation (osteogenesis) at the site of the lengthening. The procedure basically involves breaking a bone of the leg and attaching pins through the leg into the bone. The pins pull the bones apart by about 0.4 in (1 mm) each day and the bone grows new bone to try to mend the gap. It takes about a month to grow an inch (2.5 cm).

Leg lengthening surgery is usually recommended for severe unequal leg lengths resulting from:

- poliomyelitis, cerebral palsy, or septic arthritis
- small, weak (atrophied) muscles
- short, tight (spastic) muscles
- hip diseases, such as Legg-Perthes disease
- previous injuries or bone fractures that may have stimulated excessive bone growth
- scoliosis (abnormal spine curvature)
- birth defects of bones, joints, muscles, tendons, or ligaments

Guidelines for treatment are tailored to patient needs and are usually as follows:

- LLD < 0.79 in (2 cm): Orthotics (lift in shoe)
- LLD = 0.79-3.2 in (2-6 cm): Epiphysiodesis or shortening procedure
- LLD > 3.2 in (6 cm): Lengthening procedure
- LLD > 5.9-7.9 in (15-20 cm): Lengthening procedure, staged or combined with epiphysiodesis (**Amputation** is done if the procedure fails.)

Demographics

According to the Maryland Center for Limb Lengthening and Reconstruction, the rate of increase of the leg length difference is progressive in the United States with one-fourth of the LLD present at birth, one-third by age one year, and one-half by age three years in girls and four years in boys.

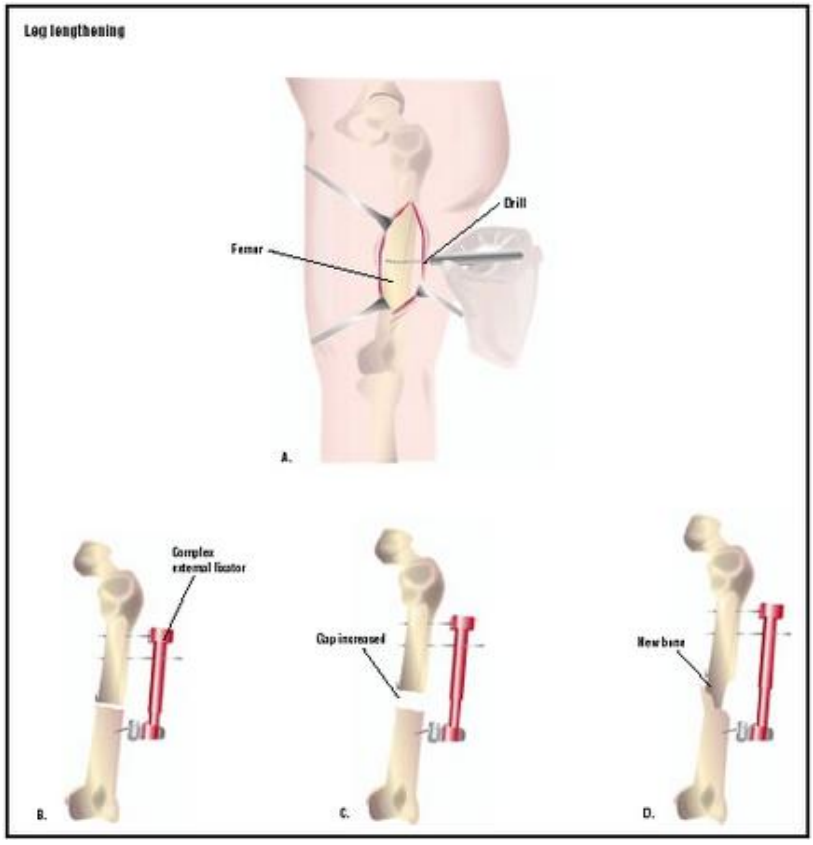
LLD is common in the general population, with 23% of the population having a discrepancy of 0.4 in (1 cm) or more. One person out of 1000 requires a corrective device such as a shoe lift.

Description

Leg lengthening

Leg lengthening is performed under general anesthesia, so that the patient is deep asleep and can't feel pain. Of the several surgical techniques developed, the **Ilizarov method**, or variation thereof, is the one most often used. An osteotomy is performed, meaning that the bone to be lengthened is cut, usually the lower leg bone (tibia) or upper leg bone (femur). Metal pins or screws are inserted through the skin and into the bone. Pins are placed above and below the cut in the bone and the skin incision is stitched closed. An external fixator is attached to the pins in the bone, which is used after surgery to gradually pull the cut bone apart, creating a gap between the ends of the cut bone in which new bone growth can occur. The fixator functions much like a bone scaffold and will be used very gradually, so that the bone lengthens in extremely small steps. The original Ilizarov external fixator consists of stainless steel rings connected by threaded rods. Each ring is attached to the underlying bone segment by two or more wires, placed under tension to increase stability, yet maintain axial motion. Titanium pins are also used for supporting the bone segments. Several fixators are available and the choice depends on the desired goal and on specific patient requirements.

Other surgical techniques, such as the Wagner method, or acute lengthening, are used much less commonly. The Wagner technique features more rapid lengthening followed by **bone grafting** and plating. The advantage of the Ilizarov technique is that it does not require an additional procedure for grafting and plating. However, there are reports indicative of higher pain scores associated with the Ilizarov method and conflicting reports concerning the level of complications associated with each technique.



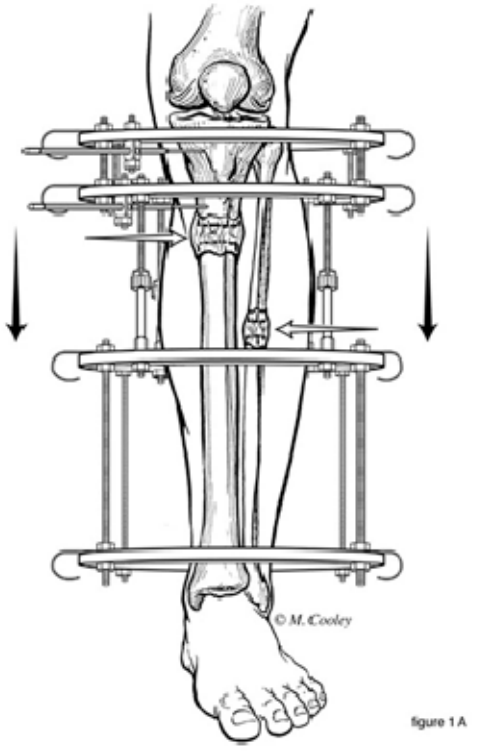


Figure 1A A circular external fixator with wires and pins to affix the bones to the fixator

To lengthen a leg surgically, an incision is made in the leg to access the femur (A). A surgical drill is used to weaken the femur so the surgeon can break it. During the operation, screws are drilled into the bone on both sides of the break, and an external fixator is applied (B). The gap between the two pieces of bone is increased gradually (C), so new bone growth results in a longer leg (D). (Illustration by GGS Inc.)

Diagnosis/Preparation

LLD is a common problem that is frequently discovered during the growing years. A medical history specific to the problem of limb length discrepancy, is taken by the treating physician to provide information as to the cause of discrepancy, previous treatment, and neuromuscular status of the limb. The patient is first evaluated standing on both legs to assess pelvic obliquity, relative height of the knees, presence of angular deformity, foot size, and heel pad thickness. Overall discrepancy is assessed by having the patient stand with the shorter leg on graduated blocks until the pelvis is leveled. Examination is then performed with the patient prone, hips extended and knees flexed to 90 degrees. In this position, the respective lengths of the femur and tibia segments of the two legs can be compared, and the relative contribution of the difference within each segment to the overall LLD can be roughly assessed.

Imaging studies, such as x rays, are the diagnostic tool of choice to fully evaluate the patient. A leg series of x rays shows the overall picture of the affected leg. The extent of LLD and required alignment can be measured with precision, and bone abnormalities involving specific parts of the leg can also be seen. The x rays are usually repeated at six to 12 month intervals to establish the growth pattern of the limbs. When several determinations of limb length have been compiled, the remaining growth and the ultimate discrepancy between the legs can be calculated, and a treatment plan selected based on predicting future growth and discrepancy, which is in turn dependent on an accurate record of past and present growth. Treatment is rarely started solely on the basis of a single determination of the existing discrepancy in a skeletally immature child. **CT scans** are not performed routinely but may be helpful in confirming the diagnosis or more accurately measure the amount of discrepancy.

For LLD patients with a nonfunctional foot, most physicians recommend amputation. In patients with a functional foot, the surgical procedure recommendations generally fall into one of the following three groups:

- The first group involves patients with a leg discrepancy less than 10%. There is little disagreement that these patients can benefit from lengthening procedures.
- The second group involves patients with a leg discrepancy exceeding 30%. Amputation is usually recommended for these patients.
- The third group involves patients a discrepancy ranging between 10 and 30%. Lengthening more than 4 in (10 cm) in a leg with associated knee, ankle, and foot abnormalities is very complex. At skeletal maturity, an average lower-extremity length is often 31.5–39.4 in (80–110 cm) and a 10% discrepancy represents 3.1–4.3 in (8–11 cm).

In the case of leg lengthening, the patient is also seen and evaluated for the design of the external fixator before surgery.

One week before surgery, patients are usually scheduled for a blood and urine test. They are asked to have nothing at all to eat or drink after midnight on the night before surgery.

Aftercare

After the operation, nursing staff teach patients how to clean and care for the skin around the pins that attach the external fixator to the limb (pinsite care). Patients are also shown how to recognize and treat early signs of infection and not to neglect pinsite care, which takes about 30 minutes every day until the apparatus is removed. It is very important in preventing infection from developing.

In the case of leg lengthening surgery, hospitalization may require a week or longer. Intensive physical therapy is required to maintain a normal range of leg motion. Frequent visits to the treating physician are also required to adjust the external fixator and attentive care of the pins holding the device is essential to prevent infection. Healing time depends on the extent of lengthening. A rule of thumb is that each 0.4 in (1 cm) of lengthening requires some 36 days of healing. A large variety of external fixators are now available for use. Today's fixators are very durable, and are generally capable of holding full weight. Most patients can continue many normal activities during the three to six months the device is worn.

Metal pins, screws, staples, rods, or plates are used in leg lengthening/shortening surgery to stabilize bone during healing. Most orthopedic surgeons prefer to plan to remove any large metal implants after several months to a year. Removal of implanted metal devices requires another surgical procedure under general anesthesia.

During the recovery period, physical therapy plays a very important role in keeping the patient's joints flexible and in maintaining muscle strength. Patients are advised to eat a nutritious diet and to take calcium supplements. To speed up the bone healing process, gradual weight-bearing is encouraged. Patients are usually provided with an external system that stimulates bone growth at the site, either an ultrasound device or one that creates a painless electromagnetic field.

Risks

All the risks associated with surgery and the administration of anesthesia exist, including adverse reactions to medications, bleeding and breathing problems.

Specific risks associated with LLD surgery include:

- osteomyelitis (bone infection)
- nerve injury that can cause loss of feeling in the operated leg
- injury to blood vessels
- poor bone healing (non-union)
- avascular necrosis (AVN) of the femoral head as a result of vascular damage during surgery
- chondrolysis (destruction of cartilage) following insertion of rods and pins
- hardware failure, failure of epiphysiodesis, failure of slip progression
- unequal limb lengths if one leg fails to heal properly (The physician may need to reverse the direction of the external fixator device to strengthen it, causing a slight discrepancy between the two legs.)
- joint stiffness (contractures) may occur during lengthening, especially significant lengthenings
- pin loosening in the anchor sites

Another serious specific risk associated with leg lengthening/shortening surgery is infection of the pins or wires going through the bone and/or resting on the skin that may result in further bone or skin infections (osteomyelitis, cellulitis, staph infections).

Normal results

Bone lengthening is completely successful only 40% of the time and has a much higher rate of complications. Recovery time from leg lengthening surgery varies among patients, with the consolidation phase sometimes lasting a long period, especially in adults. Generally speaking, children heal in half the time as it takes an adult patient. For example, when the desired goal is 1.5 in (3.8 cm) of new bone growth, a child will wear the fixation device for some three months while an adult will need to wear it for six months.

Alternatives

A LLD of 0.8 in (2 cm) or less is usually not a functional problem and non-surgical treatment options are preferred. The simplest forms do not involve surgery:

- Orthotics. Often leg length can be equalized with a sole or heel lift attached to or inserted inside the shoe. This measure can effectively level a difference of 0.4–2.0 in (1.0–5.0 cm) and correct about two thirds of the LLD. Up to 0.4 in (1 cm) can be inserted in a shoe. Beyond this, the lift gets heavy, awkward, and can cause problems such as ankle sprains and falls. The shoes look unsightly and patients complain of gait instability with such a large lift. A foot-in-foot prosthesis can be used for larger LLDs but they tend to be bulky and used as a temporary measure.
- Physical therapy. LLD results in the pelvis tilting sideways since one side of the body is higher than the other side. In turn, this causes a "kink" in the spine known as a scoliosis. Thus, leg length discrepancies can alter the mechanics of the pelvis so that the normal stabilizing and controlling action of specific muscles is altered. A common approach is to use exercises designed to modify the mechanics through specific strengthening of muscles that are weak and stretching of muscles that are restricting movement.

See also Amputation .