Operative Technique

by

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LIMB LENGTHENING AND CORRECTION OF DEFORMITIES BY CALLUS DISTRACTION

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INTRODUCTION

This technique is a method of gradual distraction which is based upon the fundamental biological principle that bone forms naturally under these circumstances (2, 4, 6).

During distraction, the tissue between the bone segments is transformed into connective tissue consisting of networks running parallel to the direction of distraction. Fibroblasts located within the network of collagen fibres are transformed into osteoblasts, producing the bone substance which cements the ends of the osteotomy together. The bony trabeculae, formed in this manner, are disposed in the direction of distraction. They thicken and anastomose, forming primitive bone. During neutralization (i.e. the period following distraction, with the body locking nut tightened), the trabeculae increase and become more compact under dynamic loading. At this point, the remodelling and corticalization process has already started (2).

The dynamics of this biological process indicate that distractional osteogenesis involves a process of intramembranous ossification.

Three conditions are necessary:
- Integrity of the periosteum, since the internal surface is osteogenic and the trabeculae are laid down on this surface in the correct orientation (5).
- Stability of the bone segments, since excessive movement between the bone ends causes cartilagenous tissue to be formed with discontinuity in the new bone.
- A gradual rate of distraction, which avoids disruption of the vascular connective tissue (1, 3).

The aim of callus distraction is to stimulate the proliferation of osteogenic elements by increasing the biosynthetic activity of the cellular components in order to rapidly obtain bony tissue. This is achieved by the osteotomy technique and the subsequent phases.

The sub-periosteal osteotomy stimulates the regenerative capacity of the bony tissue, in that it creates appropriate biological conditions for periosteal ossification.

A metaphyseal site for the osteotomy ensures a good blood supply to the distal segment, reducing vascular problems; the periosteum is also thicker at this point.

The waiting period preceding distraction allows the lesions caused by the osteotomy to heal and ensures abundant and well-vascularized callus formation (7). Osteogenesis is enhanced when distraction is carried out under these conditions, whereas it is arrested when ischaemia is present (5).

The slow rate of distraction, effected in several stages over a 24 hour period, does not lead to discontinuity in the vascular connective tissue which would compromise the new bone.

Slow distraction is also less likely to cause pain or oedema in the tissues.

Stability of the bone segments is ensured by the inherent stability of the system.

The axial dynamic movement, permitted at the appropriate time by the telescopic structure of the fixator, enhances cortex formation.

Movement and weightbearing are integral to the healing process, since they improve oxygenation of the tissues, stimulate muscle and joint function and assist in maintaining normal social activities.
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EQUIPMENT REQUIRED

a) A lengthening device (fixator without ball-joints) is used for this application. The model to be used is selected in relation to the dimensions of the bone and the extent of lengthening envisaged. A smaller lengthener may be replaced by a longer model at a later stage.

<table>
<thead>
<tr>
<th>Catalogue N°</th>
<th>Model</th>
<th>Distance between outer screws</th>
<th>Maximum extent of lengthening</th>
</tr>
</thead>
<tbody>
<tr>
<td>20001</td>
<td>Long</td>
<td>23.7 cm</td>
<td>9.5 cm</td>
</tr>
<tr>
<td>20000</td>
<td>Standard</td>
<td>19.2 cm</td>
<td>5.0 cm</td>
</tr>
</tbody>
</table>

b) Five or six cortical screws, diameter 6/5 mm, are normally used. In cases where the bone diameter is less than 20 mm, screws with a thread diameter 4.5/3.5 mm should be used. Screw length and thread length can be estimated by reference to the patient’s X-rays, using the Orthofix transparent X-ray overlay. Thread length should be such that about 5 mm of thread will remain outside the entry cortex and about 2 mm will project beyond the second cortex.

The use of OsteoTite (H A-Coated) bone screws is strongly recommended for this application.

c) The standard instrumentation (see Manual 1, “General Application Instructions”) is used together with the rigid guide template; for long and standard lengtheners (20001, 20000) use template 11113.

N.B.: The template 11113 must be used fully closed for standard lengthener 20000 and fully open for long lengthener 20001.
Normally five cortical screws are used, three proximal and two distal. In cases of extensive lengthening or in obese patients the use of six screws is advisable.

The lengthener is applied to the lateral aspect of the femur. The technique for inserting individual screws is explained in detail in Manual 1, “General Application Instructions”. In essence, this section emphasizes the importance of using the template kit on every occasion to ensure that screws are inserted parallel to one another and at right angles to the axis of the bone. This avoids undue stress on any screw in a group and is a safeguard against osteolysis and loosening. It also explains the importance of using screw guides and drill guides to minimize soft tissue trauma. Note also that because the screw thread is conical in its design, any attempt to back a screw out once it has been inserted will cause it to become loose.

The most proximal screw is inserted first. It is placed in the base of the neck of the femoral head when the growth plate of the greater trochanter is closed or below the growth plate when open. Image intensification is recommended to achieve correct screw placement. The drill bit is initially laid on the surface of the thigh to check the drilling site and to ensure that the direction of drilling is perpendicular to the long axis of the bone. The Image Intensifier is used when the screw is inserted to ensure that the threaded portion penetrates the medial cortex and that the smooth shank does not reach the lateral cortex.

Using the template, the first screw is placed in the second most proximal seat of the proximal clamp. This will ensure that the osteotomy can be performed just below the lesser trochanter and not more distally.

The next screw is placed in the most distal seat of the distal screw clamp. This will ensure correct positioning of the remaining screws, which must be defined at this stage, since the rigid nature of the device will not allow subsequent correction.
The remaining screws are now inserted in the normal way, using the Image Intensifier to ensure that they are positioned correctly. Once all the screws have been inserted, the template is removed and a small longitudinal incision is made laterally between the two groups of screws. A transverse fasciotomy is performed through this incision in order to reduce soft tissue tension during lengthening. The skin incision is then closed.

The lengthener is now applied with the central body locking nut loosened. The compression-distraction unit is mounted and a few millimetres of distraction applied.

The osteotomy is now performed about 1.5 cm below the most distal screw in the proximal clamp. The bone is exposed via an anterior incision dividing the deep fascia and proceeding between the rectus femoris medially and the vastus lateralis laterally, separating the fibres of vastus intermedius to expose the periosteum covering the femur. The periosteum must be incised longitudinally and carefully detached from the cortex. Bone levers are placed on either side of the bone to hold the muscle and periosteum away from the bone surface.

Holes are now drilled from the anterior face of the bone to penetrate the posterior cortex and in the lateral and medial cortices as far back as possible. The holes are drilled very close to one another, using the drill and the screw guide. The tip of the screw guide is used to engage the previous hole in order to obtain a stable drilling position.
The holes are joined together with an osteotome and the osteotomy should now be complete, because the posterior wall will break spontaneously due to the previous tensioning of the frame.

To ensure that the osteotomy is complete, the compression-distraction unit is used to separate the segments, noting that they move apart without significant resistance. If this is not the case, it indicates that a bony bridge still exists, most probably in the posterior cortex. In these circumstances the osteotome or the drill is used to complete the osteotomy.

The two segments are then brought together again under slight compression.

The central body locking nut is now tightened. The compression-distraction unit is put into slight distraction. The incision is closed.
The knee is now flexed and extended to ensure that the skin around the screws is not under tension and to allow for easy movement of muscles and fascia. An X-ray is taken to check that the lengthener has been mounted parallel to the diaphysis.

**POST-OPERATIVE MANAGEMENT**

The patient should commence weightbearing with crutches the day after the operation.

The waiting period before starting distraction is normally ten days in adults and about five days in children and patients with rapid ossification (i.e. achondroplastic patients or patients who have suffered severe head trauma). The rate of distraction should be 1 mm per day, achieved by four counter-clockwise quarter turns per day of the compression-distraction unit (0.25 mm every 6 hours). The rate of distraction should be temporarily increased where rapid ossification is observed or reduced if ossification is slow or the patient complains of pain or muscle contraction.

After 1 cm of lengthening has been achieved, an X-ray or an ultrasound is performed to ensure that distraction is taking place correctly. The patient is then allowed to leave hospital.

An X-ray is then taken every 30-40 days to check that osteogenesis is occurring, in which case lengthening is continued. If the density of the lengthened portion is poor but uniform, lengthening is stopped for one or two weeks. If the callus is irregular, the segment is compressed by one or two centimetres at the same rate as for lengthening, until the callus is uniform, when lengthening is resumed.

At the end of lengthening, the X-ray should show a uniform callus. The lengthener body is now locked to maintain the new bone in stable neutralization. The compression-distraction unit is no longer required and is removed at this stage to make the assembly lighter. The duration of the neutralization period will vary depending upon the amount of lengthening achieved, the aetiology of the condition, and the age of the patient.
When the X-ray shows that the segment is uniformly dense and opaque, dynamization is commenced by loosening the central body locking nut.

A Dyna-Ring dynamization collar (10010) is also available. This incorporates a silicone cushion and is attached to the stem of the male part of the lengthener. It will permit limited micromovement of up to 2mm on weightbearing, thus preventing collapse of the newly-formed bone and, at the same time, allowing earlier conversion to the dynamic mode.

A guide to its use is as follows: when, after a variable period in neutralization, the callus shows evidence of early corticalization, the Dyna-Ring is attached with its silicone cushion facing the rim of the female part of the lengthener and just in contact with it. The central body locking nut is now loosened and the telescopic action of the lengthener confirmed.

The patient is then reviewed after a further 2-4 weeks. If the Dyna-Ring cushion appears compressed, the central body locking nut is again locked, and the Dyna-Ring offset from the female part of the lengthener until it has regained its shape and is once again just in contact with the female part. When on subsequent review, the Dyna-Ring no longer appears compressed, it may be left in this position until full corticalization is evident.

During dynamization, weightbearing on the lengthened limb should be total. Full corticalization of the new bone takes a minimum of 30 days.

The lengthener is removed once X-rays and clinical assessment indicate good bony consolidation. The screws, however, are left in place for several days under conditions of full, free weightbearing to ensure that healing is complete. The screws are then removed. Radiological and clinical review should be carried out 6 months after fixator removal.

Pin Site Care

The visible parts of the screws and surrounding skin should be cleaned on the day following application of the lengthener and at least once a day thereafter. Only sterile water should be used for this purpose. A dry absorbent dressing with additional gauze is used around the pin sites. After a few days, when they are dry, no dressing is needed.

There may be some loss of serous fluid especially in overweight patients. This should not be mistaken for infection and is not a true complication. It may be the result of excessive patient mobility and subsequent irritation of the tissues around the screws. Normal care on pin cleaning is required. Where inflammation is seen and the exudate is purulent, with the skin around the screw red and warm, a bacteriological swab should be taken and the appropriate antibiotic given for 7 to 10 days.

Weightbearing should be restricted until resolution has occurred. Should local conditions not improve, the patient should return to hospital for more aggressive therapy, including possible removal of the screw or screws involved.

If X-rays taken in the pre-dynamization phase show signs of osteolysis around a screw and there is clinical evidence of screw loosening, it is advisable to reposition the screw, if simple removal would compromise the stability of the assembly. Special care should be taken when repositioning a screw since osteolysis usually implies that the procedure for screw insertion has not been strictly adhered to.
POSSIBLE COMPLICATIONS

Early Fusion of the Osteotomy
This may occur before or during distraction. It may be caused by an incomplete osteotomy, waiting too long before starting distraction, or excessively rapid bone formation, such as occurs in patients who have suffered severe head trauma. When this happens, the lengthener will not open and X-rays show that the segments have not separated symmetrically and that the screws are bent.

Absence of Consolidation
The situation is similar to that of an atrophic non-union.

Axial Deviation
This may occur on fixator removal when the callus is still plastic and is due to increased muscular tension or weightbearing.

Fracture
This may occur if the lengthener is removed before the lengthened segment is sufficiently consolidated.

Regional Problems
These may occur due to stretching of the soft tissues or to articular dysplasia.

Pin Site Problems

RECOMMENDED ACTIONS

Where fusion has already taken place, the callus must be broken by closed manipulation, or failing this, the osteotomy must be repeated.

Treatment is always surgical and involves mechanical stabilization with or without bone grafting, as indicate.

This complication may be avoided if the adequacy of bony consolidation is checked both clinically and radiologically prior to fixator removal. If deviation occurs, surgical correction is indicated.

It is possible to prevent fracture by extending the dynamization period, especially where significant lengthening has been achieved. If fracture has already occurred but the screws are still in situ, it is possible to refit the lengthener without the need for further action. Where the screws have already been removed, a plaster cast may be sufficient, but sometimes it is better to refit the lengthener and to recommence dynamization with weightbearing as soon as possible.

A slow rate of distraction reduces the likelihood of soft tissue problems. Particular care should be taken in congenital cases. The use of a unilateral device preserves good muscular function since it is mounted on the lateral aspect of the femur where it causes only temporary limitation of knee movement.

See page 8 on Pin Site Care.
**CALLOTASIS - TIBIA**
(Using the telescopic lengthener)

**EQUIPMENT REQUIRED**

a) A lengthening device (fixator without ball-joints) is used for this application. The model to be used is selected in relation to the dimensions of the bone and the extent of lengthening envisaged. A smaller lengthener may be replaced by a longer model at a later stage.

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<td>19.2 cm</td>
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b) Five or six cortical screws. The thread diameter of the screws will depend upon the bone diameter: 6/5 mm for bones with a diameter greater than 20 mm; 4.5/3.5 mm for smaller bones. Screw length and thread length can be estimated by reference to the patient’s X-rays, using the Orthofix transparent X-ray overlay. Thread length should be such that about 5 mm of thread will remain outside the entry cortex and about 2 mm will project beyond the second cortex. **The use of OsteoTite (H A-Coated) bone screws is strongly recommended for this application.**

N.B.: When using 6/5 mm cortical screws in cancellous bone, pre-drilling should be performed with a 3.2 mm drill bit.

c) The standard instrumentation (see Manual 1, “General Application Instructions”) is used together with the rigid guide template; for long and standard lengtheners (20001, 20000) use template 11113.

N.B.: The template 11113 must be used fully **closed** for standard lengthener 20000 and fully **open** for long lengthener 20001.
Normally five screws are used for this application. In cases of extensive lengthening or in obese patients the use of six screws is advisable. The lengthener is mounted in an antero-medial position on the tibia.

The fibula is fixed to the tibia with a screw to prevent any displacement of the malleolus during the lengthening procedure. About 2 cm of the fibula are then removed above the syndesmosis.

The most proximal screw is placed first. It is inserted about 2 cm below the joint or the growth plate, using the first (or second) most proximal seat of the rigid template. The technique for inserting individual screws is explained in detail in Manual 1, "General Application Instructions". In essence, this section emphasizes the importance of using the template kit on every occasion to ensure that screws are inserted parallel to one another and at right angles to the axis of the bone. This avoids undue stress on any screw in a group and is a safeguard against osteolysis and loosening. It also explains the importance of using screw guides and drill guides to minimize soft tissue trauma. Note also that because the screw thread is conical in its design, any attempt to back a screw out once it has been inserted will cause it to become loose.

The next screw is placed in the most distal seat of the distal screw clamp. This will ensure correct positioning of the remaining screws, which must be defined at this stage, since the rigid nature of the device will not allow subsequent correction.
When the remaining screws have been inserted, the template is removed and the lengthener applied with the central body locking nut loosened. The compression-distraction unit is then mounted and a few millimetres of distraction applied.

The bone is exposed via an anterior longitudinal incision about 1.5 cm below the distal screw in the proximal clamp, just below the insertion of the patellar tendon. A fasciotomy of the lateral compartment only may be performed through this incision in order to reduce soft tissue tension during lengthening. Tibial osteotomy is then performed through the same skin incision and the technique used is identical with that described for Callotasis - Femur (see pages 5-6).

To ensure that the osteotomy is complete, the compression-distraction unit is used to separate the segments, noting that they move apart without significant resistance. If this is not the case, it indicates that a bony bridge still exists, most probably in the posterior cortex. In these circumstances the osteotome or the drill is used to complete the osteotomy.

The two segments are then brought together again under slight compression and the periosteum stitched back. Finally, the central body locking nut is tightened and the compression-distraction unit is put into slight distraction. The incision is closed. Where lengthening in excess of 4 cm is envisaged, it is advisable to perform a subcutaneous tenotomy of the Achilles tendon.
POST-OPERATIVE MANAGEMENT

The patient should commence weightbearing with crutches the day after the operation.

The waiting period before starting distraction is normally ten days in adults and about five days in children and patients with rapid ossification (i.e. achondroplastic patients or patients who have suffered severe head trauma).

The rate of distraction should be 1 mm per day, achieved by four counter-clockwise quarter turns per day of the compression-distraction unit (0.25 mm every 6 hours).

The rate of distraction should be temporarily increased where rapid ossification is observed or reduced if ossification is slow or the patient complains of pain or muscle contraction.

After 1 cm of lengthening has been achieved, an X-ray or an ultrasound is performed to ensure that distraction is taking place correctly. The patient is then allowed to leave the hospita.

An X-ray is then taken every 30-40 days to check that osteogenesis is occurring, in which case lengthening is continued. If the density of the lengthened portion is poor but uniform, lengthening is stopped for one or two weeks.

If the callus is irregular, the segment is compressed by one or two centimetres at the same rate as for lengthening, until the callus is uniform, when lengthening is resumed.

At the end of lengthening, the X-ray should show a uniform callus. The lengthener body is now locked to maintain the new bone in stable neutralization.

The compression-distraction unit is no longer required and is removed at this stage to make the assembly lighter.

The duration of the neutralization period will vary depending upon the amount of lengthening achieved, the aetiology of the condition, and the age of the patient.

When the X-ray shows that the segment is uniformly dense and opaque, dynamization is commenced by loosening the central body locking nut. A Dyna-Ring dynamization collar is also available (see page 8).

During dynamization, weightbearing on the lengthened limb should be total.

Full corticalization of the new bone takes a minimum of 30 days.

The lengthener is removed once X-rays and clinical assessment indicate good bony consolidation.

The screws, however, are left in place for several days under conditions of full, free weightbearing to ensure that healing is complete.

The screws are then removed.

Radiological and clinical review should be carried out 6 months after fixator removal.

Pin Site Care
See page 8.

POSSIBLE COMPLICATIONS

Early Fusion of the Osteotomy
This may occur before or during distraction.
It may be caused by an incomplete osteotomy, waiting too long before starting distraction, or excessively rapid bone formation, such as occurs in patients who have suffered severe head trauma.
When this happens, the lengthener will not open and X-rays show that the segments have not separated symmetrically and that the screws are bent.

RECOMMENDED ACTIONS

Where fusion has already taken place, the callus must be broken by closed manipulation, or failing this, the osteotomy must be repeated.
Absence of Consolidation
The situation is similar to that of an atrophic non-union.

Axial Deviation
This may occur on fixator removal when the callus is still plastic and is due to increased muscular tension or weightbearing.

Fracture
This may occur if the lengthener is removed before the lengthened segment is sufficiently consolidate.

Regional Problems
These may occur due to stretching of the soft tissues or to articular dysplasia.

Pin Site Problems
A slow rate of distraction reduces the likelihood of soft tissue problems. Particular care should be taken in congenital cases. The use of a unilateral device preserves good muscular function of the leg and foot since it is mounted on the anterior or antero-medial aspect of the tibia.

See page 8.
The Orthofix Limb Reconstruction System was developed primarily for multilevel surgery, such as bone transport or bifocal lengthening, and its use in these indications is described fully in Manual 11, Part A, “The Limb Reconstruction System-General Principles”. When used for multilevel surgery, three, and occasionally even four clamps are attached to the rail.

It can also be used, however, for monofocal lengthening in association with callotasis at a single osteotomy site. When used in this way, only two clamps are needed, and the length of the rail is selected according to the dimensions of the limb involved and the amount of lengthening required.

The indications for use of the Limb Reconstruction System for monofocal lengthening include application to very short bone segments where the smallest possible distance between proximal and distal clamps is required. In these circumstances it may not be possible to use an Orthofix telescopic lengthener, since with this model, the minimum distance possible between the clamps is dictated by the length of the body of the device.

It is also recommended for lengthenings in excess of 10cm, where its extreme rigidity is of particular value and in femoral lengthenings in children or patients of short stature, where the distal clamp must be positioned as far as possible from the knee joint in order to preserve joint function.

Finally, it may be used for lengthening in association with angular correction. In such cases, correction of the deformity is performed with the aid of special clamps (see Manual 11, Part B, “The Limb Reconstruction System-Correction of Deformities”).
HEMICALLOTTASIS - FEMUR AND TIBIA

EQUIPMENT REQUIRED

a) Appropriate Dynamic Axial Fixator: this is selected according to the length of the limb.

<table>
<thead>
<tr>
<th>Catalogue N°</th>
<th>Model</th>
<th>Minimum distance between outer screws when a T-clamp and self-aligning body* used</th>
</tr>
</thead>
<tbody>
<tr>
<td>10000</td>
<td>Standard D.A.F.</td>
<td>22.6 cm</td>
</tr>
<tr>
<td>31000</td>
<td>Blue Small D.A.F.</td>
<td>16.9 cm</td>
</tr>
</tbody>
</table>

* N.B.: The distance between the outer screws refers to a fixator with the axis of the self-aligning body parallel to the axis of the fixator body.

b) One T-clamp (10007 or 31007).

c) A self-aligning articulated body (10036 or 30036).

d) Four cortical screws.
   The thread diameter of the screws should be 6/5 mm for bones with a diameter greater than 20 mm and 4.5/3.5 mm for smaller bones.
   Screw length and thread length can be estimated by reference to the patient’s X-rays, using the Orthofix transparent X-ray overlay.
   The dimensions of the screws for the epiphysis must be selected with great care. Thread length should be such that about 5 mm of thread will remain outside the entry cortex and about 2 mm will project beyond the second cortex.
   The use of OsteoTite (H A-Coated) bone screws is strongly recommended for this application.

N.B.: When using 6/5 mm cortical screws in cancellous bone, pre-drilling should be performed with a 3.2 mm drill bit.

e) The guide template for fitting the self-aligning articulated body (11136 or 13136).

f) The standard instrumentation (see Manual 1, “General Application Instructions”) is used together with guide template 11101 for standard fixator (10000), and 13101 for blue small fixator (31000). The template must be applied fully closed.
Instructions for the preparation of a STANDARD D.A.F. (10000) with articulated body (10036) and related templates (11101 and 11136).

To fit the articulated body (10036) to the fixator (10000), first remove the male part (10018).

Replace with the articulated body (10036).

Remove cam (10004) and bush (90005) from the male part (10018) of the standard body and attach them to the articulated body (10036).

Fit the T-clamp (10007) on to the articulated body. Attention should be paid to the position of the compression-distraction unit (10008). This is fitted by inserting one shank into the cam of the female part of the standard body and the other into the seat on the articulated body as shown, so that the joint is still free to move.
Prepare the template (11101) by removing the inner male body and the clamp.

Replace the inner male body with the guide template for the self-aligning articulated body (11136). Rotate the clamp template for use with the T-clamp (10007).

Instructions for the preparation of a BLUE SMALL D.A.F. (31000) with articulated body (30036) and related templates (13101 and 13136).

To fit the articulated body (30036) to the fixator (31000), first remove the external female part (30019).

Replace with the articulated body (30036).
Remove cam (30004) and bush (31005) from the external female part (30019) of the small body and attach them to the articulated body (30036).

Fit the T-clamp (31007) on to the articulated body. Attention should be paid to the position of the compression-distraction unit (30008). This is fitted by inserting one shank into the cam of the male part of the small body and the other into the seat on the articulated body as shown, so that the joint is still free to move.

Prepare the template (13101) by removing the inner male body and the clamp.

Replace the inner male body with the guide template for the self-aligning articulated body (13136). Rotate the clamp template for use with the T-clamp (31007).
General Principles:
The fixator must always be positioned in the concave part of the deviation. The epiphyseal screws are always inserted first, parallel to the articular surface. The fixator is positioned so that the arc of movement of the articulated body is in the frontal plane. The angle between the axis of the fixator and the axis of the self-aligning body must reflect that of the deformity. The body of the fixator must be parallel to the longitudinal axis of the bone. The sliding pivot of the self-aligning body (which provides automatic compensation for minimal transverse movement of the epiphysis) must be positioned in that end of the slot nearest to the bone segment to allow movement of the articulated component away from the bone during distraction.

Valgus Knee (Deviation of the distal femur):
The epiphyseal screws are inserted first. The technique for inserting individual screws is explained in detail in Manual 1, “General Application Instructions”. In essence, this section emphasizes the importance of using the template kit on every occasion to ensure that screws are inserted parallel to one another and at right angles to the axis of the bone. This avoids undue stress on any screw in a group and is a safeguard against osteolysis and loosening. It also explains the importance of using screw guides and drill guides to minimize soft tissue trauma. Note also that because the screw thread is conical in its design, any attempt to back a screw out once it has been inserted will cause it to become loose. The first screw to be placed is the anterior screw. It should be positioned about 2 cm proximal to the knee joint and this should be monitored with an Image Intensifier. The 3.2 mm drill bit must always be inserted parallel to the articular surface, approximately 1 cm below the edge of the lateral condyle. This prevents the screw passing through the intercondylar notch, which might cause the patella to rub against it.
Using the clamp template in the “T” configuration, the second screw is now positioned. It is advisable to leave the maximum distance between these two distal screws to achieve a balanced load. In practice, this generally means placing the screw in the 3rd or 4th seat of the clamp template behind the anterior screw. Care should be taken to ensure that it is also parallel to the knee joint. No articular problems will result if the screw passes through the posterior intercondylar notch. Both epiphyseal screws must be positioned at the first attempt, thus avoiding extra holes in the epiphysis which might weaken the bone.

The appropriate fully closed body template is now attached and the two proximal screws inserted, using the two outer seats of the clamp template if possible. Care should be taken to ensure that the body template is in line with and parallel to the femoral diaphysis.
The osteotomy is performed laterally in a distal metaphyseal site after removal of the template. The lateral cortex is broken by drilling holes and joining them with an osteotome, as described for Callotasis (see pages 5-6). The osteotomy is then extended around the anterior and postero-lateral cortices until satisfactory opening is achieved. The medial cortex should not be broken.

A useful way of selecting the appropriate osteotomy site is to mount the fixator assembly temporarily on the bone screws, with the body of the fixator parallel to the long axis of the bone and to pass a trocar through the cam of the self-aligning articulated body down to the bone surface. The area thus identified for the osteotomy will allow ideal opening without axis deviation.

Once the fixator has been applied, the compression-distraction unit should be used to make sure that the osteotomy opens unilaterally and that correction is achievable before bringing the segments back into contact. An X-ray should be taken to ensure that the body of the fixator is parallel to the diaphysis.
Varus Knee (Deviation of the proximal tibia): A distal fibular osteotomy is performed only where the deviation is greater than 15°. The epiphyseal screws are inserted first. The technique for inserting individual screws is explained in detail in Manual 1, “General Application Instructions”. In essence, this section emphasizes the importance of using the template kit on every occasion to ensure that screws are inserted parallel to one another and at right angles to the axis of the bone. This avoids undue stress on any screw in a group and is a safeguard against osteolysis and loosening. It also explains the importance of using screw guides and drill guides to minimize soft tissue trauma. Note also that because the screw thread is conical in its design, any attempt to back a screw out once it has been inserted will cause it to become loose. The first screw to be placed is the anterior epiphyseal screw. It should be positioned about 2 cm distal to the knee joint. Positioning should be monitored with an Image Intensifier. The 3.2 mm drill bit must always be introduced parallel to the articular surface.

Subsequently, the second (posterior) screw is inserted, parallel to the first. This screw is generally placed in the 3rd or 4th seat of the clamp template behind the anterior screw.
The fully closed body template is then attached and the two distal screws inserted perpendicular to the longitudinal axis of the bone; if possible, the two outer seats of the clamp template should be used.

Once the template has been removed, the osteotomy is performed at a metaphyseal site. In general, this is proximal to the insertion of the medial collateral ligament where there is laxity of the medial compartment and distal to the insertion of the medial collateral ligament where there is no joint laxity. For selection of the appropriate osteotomy site, see page 22, upper figure. The medial cortex is broken by drilling holes and joining them with an osteotome, as described for Callotasis (see pages 5-6). The osteotomy is then extended around the anterior and postero-medial cortices until satisfactory opening is achieved. The lateral cortex should not be broken.
Once the fixator has been applied, the compression-distraction unit should be used to make sure that the osteotomy opens unilaterally and that correction is achievable before bringing the segments back into contact. An X-ray should be taken to ensure that the body of the fixator is parallel to the diaphysis.

**Varus Ankle (Deviation of the distal tibia):**
A distal fibular osteotomy is performed only where the deviation is greater than 15°. The epiphyseal screws should be inserted first. The first screw to be placed is the posterior screw, which is sited about 2 cm proximal to the ankle joint. Positioning should be monitored with an Image Intensifier. The 3.2 mm drill bit must always be introduced immediately behind the medial malleolus, parallel to the articular surface.
Using the clamp template in the “T” configuration, the second (anterior) screw is now positioned. This screw must also be introduced parallel to the joint surface. It is advisable to leave the maximum distance between these two screws.

The appropriate fully closed template body is now attached and the two proximal screws inserted, using the two outer seats of the clamp template if possible. Care should be taken to ensure that the template body is in line with, and parallel to, the tibial diaphysis.
The osteotomy is performed medially in a distal metaphyseal site after removal of the template. For selection of the appropriate osteotomy site, see page 22. The medial cortex should be broken by drilling holes and joining them with an osteotome, as described for Callotasis (see pages 5-6). The osteotomy is then extended around the anterior and posterior-medial cortices until satisfactory opening is achieved. The lateral cortex should not be broken.

Once the fixator has been applied, the compression-distraction unit should be used to make sure that the osteotomy opens unilaterally and that correction is achievable before bringing the segments back into contact. An X-ray should be taken to ensure that the body of the fixator is parallel to the diaphysis.
POST-OPERATIVE MANAGEMENT

A drain should be left in the wound for 24 hours post-operatively. It should be kept closed, but opened briefly every 3 hours to check for abnormal bleeding.

After an initial waiting period (10 days), distraction should commence at a rate of 0.25 mm every 5-6 hours (1–1.25 mm per day). An X-ray should be taken 10 days after the commencement of distraction to ensure that this is taking place on the concave side. Distraction should continue until correction is achieved. X-rays should be taken every 20-30 days.

Partial weightbearing can begin immediately post-operatively together with physiotherapy. When correction is complete, the patient should continue weightbearing with the central body locking nut tightened (neutralization period). Subsequent X-ray controls will highlight the progressive ossification of the corrected portion. Once new bone formation is adequate, the central body locking nut can be released and Dynamic Axial Loading commenced (dynamization period). A Dyna-Ring dynamization collar is also available (see page 8). When good corticalization is evident on X-ray, the Dynamic Axial Fixator may be removed. This is normally effected without anaesthetic as an outpatient procedure, leaving the screws in situ for a few days. During this period, the patient should continue to walk with full weightbearing (to provide a final clinical test of consolidation). If no complications occur, the screws may be removed.

Pin Site Care
See page 8.

POSSIBLE COMPLICATIONS

Bending of the Screws
This may occur with the epiphyseal screws if a bony bridge preventing distraction is present.

In this case an open procedure must be performed to disrupt the bony bridg.

Infection at the Fusion Site
This occurs when the body of the fixator is not parallel to the diaphysis, whenever osteotomy also involves breakage of the cortex on the convex side, or if the self-adjusting mechanism was not properly positioned.

This can be corrected by closed manipulation of the ball-joint.

Pin Site Problems
See page 8.
TIBIAL LENGTHENING AND ANGULAR CORRECTION
WITH THE OF-GARCHES LIMB LENGTHENER

INTRODUCTION

The OF-Garches limb lengthener was designed to permit tibial lengthening in the upper metaphyseal region, thus allowing better control of valgus or varus deviation. It can be used in cases of tibia vara or tibia valga for gradual or immediate angular correction.

OF-GARCHES T-CLAMP FEATURES

The T-clamp is capable of moving in one plane only and has swivelling screw seats to allow convergent sitting of the outer screws. The compression-distraction unit may be attached in one of two ways, depending upon whether lengthening or angular correction is desired.

Fig. 1 shows the position of the removable locking pin of the compression-distraction unit when lengthening along the axis of the bone is required. Fig. 2 shows the position of the removable locking pin of the compression-distraction unit when an angular correction is required.
EQUIPMENT REQUIRED

a) An OF-G arches limb lengthener 20050 or 20060, according to the length of the bone and the extent of the desired lengthening (see chart below).

<table>
<thead>
<tr>
<th>Catalogue N°</th>
<th>Model</th>
<th>Minimum bone length</th>
<th>Maximum extent of lengthening</th>
</tr>
</thead>
<tbody>
<tr>
<td>20050</td>
<td>Standard</td>
<td>23.7 cm</td>
<td>9.5 cm</td>
</tr>
<tr>
<td>20060</td>
<td>Long</td>
<td>19.2 cm</td>
<td>5.0 cm</td>
</tr>
</tbody>
</table>

b) Three or four Kirschner wires, 2.0 mm in diameter.

c) Four or five 6/5 mm cortical screws. Total screw length and thread length are selected using the Orthofix transparent X-ray overlay, in association with an appropriate lateral X-ray. The use of OsteoTite (HA-Coated) bone screws is strongly recommended for this application.

N.B.: When using cortical screws in cancellous bone, pre-drilling should be performed with a 3.2 mm drill bit.

d) The standard instrumentation (see Manual 1, “General Application Instructions”) is used together with guide template (11130). The template must be completely closed for the application of standard model (20050) and completely open for the application of long model (20060).
FIRST STAGE: Fixation and section of the fibula in its distal region.

A screw fixing the fibula to the tibia is placed obliquely from below upwards in order to prevent any displacement of the malleolus during the lengthening procedure.

About two centimetres of the fibula are then removed above the screw. The incision is closed without drainage.
SECOND STAGE: Positioning of the template.

The joint line of the knee and the anterior tuberosity of the tibia must be located by careful palpation and the use of image intensification. The template is adjusted to the appropriate length. It is kept at the correct distance from the skin by means of a guard. The T-clamp must be placed parallel to the upper surface of the tibia and in the coronal plane, since, if it is not, accurate correction in the desired plane will not be possible.

A Kirschner wire may be used as a reference point and inserted parallel to the tibial plateau, 5-8 mm below the upper border.

The upper limit of the T-clamp template should be positioned in such a way that the clamp axis locking nut is at the same level as the osteotomy site, i.e. just below the tibial tuberosity. When planning the upper limit of the T-clamp template in children, the surgeon should also bear in mind that the screws must be placed below the growth plate.
Particular care should be taken to avoid:

1. placing the T-clamp too high, with the risk of screws entering the joint or damaging the growth plate in children.
2. placing it too low, in which case the osteotomy will be in the diaphysis rather than the metaphysis.

The above steps are the most important in the technique.

Once the T-clamp template has been correctly positioned, as described above, it should be anchored temporarily to the tibia by means of Kirschner wires inserted through holes in the template designed for this purpose. Correct positioning should then be confirmed by X-ray.
The body template is now arranged so that it is parallel to the tibial diaphysis. It must be at the same distance from the bone as the T-clamp. The body template can then be anchored using Kirschner wires, inserted into the tibial crest through holes in the template for this purpose. The clamp axis locking nut of the template is then tightened.

THIRD STAGE: Screw insertion.

The proximal screws are inserted first. The technique for inserting individual screws is explained in detail in Manual 1, “General Application Instructions”. In essence, this section emphasizes the importance of using the template kit on every occasion. This avoids undue stress on any screw in a group and is a safeguard against osteolysis and loosening. It also explains the importance of using screw guides and drill guides to minimize soft tissue trauma. Note also that because the screw thread is conical in its design, any attempt to back a screw out once it has been inserted will cause it to become loose.
The screws should be inserted such that they converge as little as possible, to avoid future tension. Screw placement should be performed under image intensification to ensure that adequate penetration of the bone is achieved and that the screws project beyond the posterior cortex by not more than one thread. In children, a middle screw must not be included in the assembly, since it would damage the growth plate of the tibial tuberosity. In adults, use of this middle screw is advisable.

The diaphyseal screws are then inserted and, at this point, Kirschner wires, template and screw guides are removed.
The body of the O F-Garches limb lengthener is then positioned, without the upper clamp cover. Once the body has been fitted, the clamp cover is screwed tightly into place. The clamp axis locking nut should now be tightened.

FOURTH STAGE: Tibial osteotomy.

An antero-medial or an antero-lateral approach may be used. The periosteum is detached immediately below the tibial tuberosity and on all faces of the tibia where the osteotomy will be performed. Osteotomy is then performed at the level of the clamp axis locking nut, just below the insertion of the patellar tendon. The technique is identical with that described under Callotasis (see pages 5-6).
To check whether the osteotomy is complete, the bone segments are distracted by two or three millimetres using the compression-distraction unit (one turn anticlockwise = 1 mm distraction). The bone segments are then brought back into minimal contact (one turn clockwise = 1 mm compression). For this procedure, the compression-distraction unit must be positioned as shown in fig. 1 page 29.

The lengthener body locking nut is then tightened. Closure is by suture of the periosteum, of the muscles and finally, of the skin, without drainage.
POST-OPERATIVE MANAGEMENT

For the general principles of Post-Operative Management, including weightbearing, lengthening and pin site care, see under Callotasis-Tibia, pages 13-14.

If a varus, or more frequently, a valgus deviation appears during lengthening, its cause must first be ascertained (incomplete tightening of the clamp axis locking nut, bending of the screws, premature consolidation of the fibular osteotomy).

If angular deviation occurs before the distraction is complete (a), correction is performed with the compression-distraction unit on the same side as the deviation (b), and the position of the removable locking pin as shown in fig. 2 page 29. Distraction is then applied at a rate of 1/4 turn four times per day, with the clamp axis locking nut LOOSEned and the lengthener body locking nut TIGHTened.

Once the deviation has been corrected, the position of the removable locking pin is changed to that shown in fig. 1 page 29, and lengthening resumed.

If angular deviation is first observed at the end of the distraction period (a) and the callus is still soft, compression at a rate of 1/4 turn four times per day should be applied on the opposite side (b), after changing the position of the removable locking pin to that shown in fig. 2 page 29, with the clamp axis locking nut LOOSEned and the lengthener body locking nut TIGHTened, to avoid any risk of nerve or vascular stretching. If necessary, after changing the position of the removable locking pin to that shown in fig. 1 page 29, lengthening may be resumed once the deviation has been corrected.

When lengthening is complete, management is identical to that recommended for Callotasis (see pages 13-14).
CORRECTION OF ANGULAR DEVIATION

GRADUAL CORRECTION

For equipment required, see page 30.

An angular deviation (tibia valga, tibia vara) can be gradually corrected with the OF-G arches limb lengthener. Two different methods are suggested for this indication, the choice of which will depend upon whether the surgeon performs a complete or a partial osteotomy. In both cases the application technique is essentially the same as that used for a tibial lengthening (see pages 31-37). The waiting period before starting distraction is normally ten days in adults and less in children and patients with rapid ossification.

Where a complete osteotomy has been performed, the surgeon should determine pre-operatively the distance L shown opposite by drawing the mechanical axis for both the deformed and the corrected tibia.

Fibular osteotomy should be performed and the tibial osteotomy should be just below the insertion of the patellar tendon. The compression-distraction unit is placed in the concavity of the deviation (a) with the removable locking pin positioned as shown in fig. 1 page 29.

With the clamp axis locking nut TIGHTENED and the lengthener body locking nut LOOSENED, the osteotomy site is then gradually distracted (b) at a rate of 1/4 turn four times a day, by an amount equal to the distance L (see top figure opposite).
Once this initial distraction has been carried out, the **body locking nut** is **TIGHTENED** and the position of the removable locking pin changed to that shown in fig. 2 page 29 (c). The **clamp axis locking nut** is then **LOOSENED** and **distraction** carried out at a rate of 1/4 turn four times a day. Once the compression-distraction unit has again been extended by the distance L, the angular deformity should have been corrected (d). Once correction has been achieved, the **clamp axis locking nut** is **TIGHTENED**.

Where a **partial osteotomy** has been performed, fibular osteotomy may not be necessary, and the tibial osteotomy should be performed just below the insertion of the patellar tendon. The compression-distraction unit is placed in the concavity of the deviation (a) with the removable locking pin positioned as shown in fig. 2 page 29, ensuring that both the **clamp axis locking nut** and the lengthener **body locking nut** are **LOOSENED**. **Distraction** is performed at a rate of 1/4 turn four times per day, to avoid nerve or vascular stretching. When correction has been achieved, the **clamp axis locking nut** and the lengthener **body locking nut** are both **TIGHTENED**.

When either method is used, if limb length discrepancy is noted after angular correction has been achieved, this can be corrected using the compression-distraction unit attached as shown in fig. 1 page 29.
IMMEDIATE CORRECTION
The application technique is essentially the same as that used for a tibial lengthening (see pages 31-37). The body of the fixator should be extended by 1 to 2 cm. Tibial osteotomy is performed, using a subtraction or dome technique, 1 cm below the upper screws. Fibular osteotomy is always performed. The compression-distraction unit is placed in the convexity of the deviation (a) with the removable locking pin positioned as shown in fig. 2 page 29. The clamp axis locking nut and the lengthener body locking nut are both loosened. Compression is then carried out until the desired alignment is achieved (b). When this has been accomplished, the clamp axis locking nut is tightened and compression exerted along the axis of the bone, if needed, with the removable locking pin positioned as shown in fig. 1 page 29. This may be required to ensure effective compaction at the site of the fracture. Closure is performed without drainage.

POST-OPERATIVE MANAGEMENT
Partial weightbearing is permitted from the day following operation. Optimal alignment is best judged by means of an AP X-ray of the entire lower limb with the patient standing. Any additional correction may be achieved where necessary by means of either distraction or compression using the compression-distraction unit. A lateral X-ray is also important in order to detect any interfragmentary gap, which may be corrected by means of axial compression.
LENGTHENING WITH CORRECTION OF AN ANGULAR DEVIATION

The following technique may be used when there is angular deviation together with a shortening more than 2 cm. After a waiting period of 10 days, the compression-distraction unit is placed in the concavity of the deviation with the removable locking pin as shown in fig. 1 page 29 and distracted by 1-2 cm (a) at a rate of 1 mm per day (1/4 turn four times a day) with the clamp axis locking nut TIGHTENED and the lengthener body locking nut LOOSENED. After 1-2 cm of distraction, the lengthener body locking nut is TIGHTENED, the removable locking pin positioned as in fig. 2 page 29 (b) and the clamp axis locking nut LOOSENED. Correction is implemented at a rate of 1/4 turn four times per day.

When the tibia is correctly aligned, the clamp axis locking nut is tightened and the removable locking pin positioned as shown in fig. 1 page 29.
Lengthening recommences at a rate of 1 mm per day (1/4 turn four times a day).
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