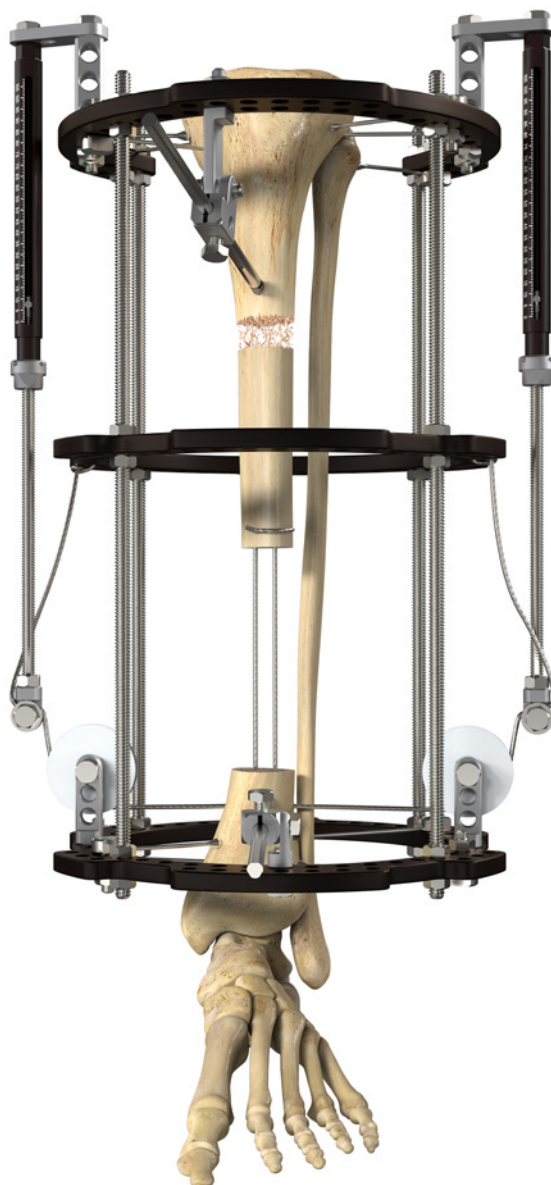










Balanced Cable Transport with Circular Fixation



Balanced Cable Transport with Circular Fixation

Surgical Technique

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Smith & Nephew thanks Stephen M. Quinnan, MD of the Paley Orthopedic & Spine Institute, for his rigorous pursuit of limb salvage and for championing this surgical technique.

Illustrations drawn by Henry Bonin, Smith & Nephew

Nota Bene

The following technique guide was prepared under the guidance of Stephen M. Quinnan, MD. It contains a summary of medical techniques and opinions based upon his training and expertise in the field, along with his knowledge of Smith & Nephew products. It is provided for educational and informational purposes only. Smith & Nephew does not provide medical advice and it is not intended to serve as such. It is the responsibility of the treating physician to determine and utilize the appropriate products and techniques according to their own clinical judgment for each of their patients. For more information on the products in this surgical technique, including indications for use, contraindications, effects, precautions and warnings, please consult the products' Instructions for Use (IFU).

The following surgical technique describes bone transport in the tibia employing a balanced internal cable with circular external fixation using components from the ILIZAROV™ and TAYLOR SPATIAL FRAME° systems. This technique offers several potential advantages over traditional bone transport including:

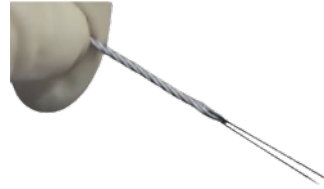
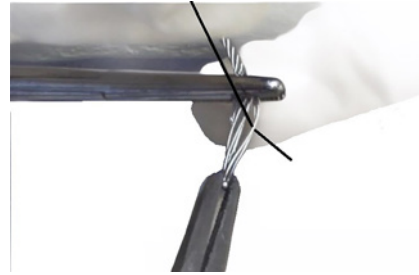
1. Ability to regenerate bone in defects greater than 10cm¹
2. Prevention of the scarring and pain that comes from Wires and Pins dragging through skin¹
3. Ability to transport beneath rotational flaps, free flaps and marginal soft tissue²
4. Fewer pin sites potentially reduces the risk of pin cellulitis
5. Facilitates multi-focal transport¹
6. Facilitates conversion to internal fixation when desired¹
7. Transport of small bone segments is facilitated by the 1.8mm Cable
8. Transport into a very small bone segment, or transport into the talus or calcaneus for fusion, is facilitated by the 1.8mm Cable and ILIZAROV™ Wire fixation

Part 1: Prepare the $\varnothing 1.8\text{mm}$, 1200mm ILIZAROV™ Cable (71970661)

Using a pair of heavy needle drivers near the end of the Cable, slightly unwind the braided Cable.

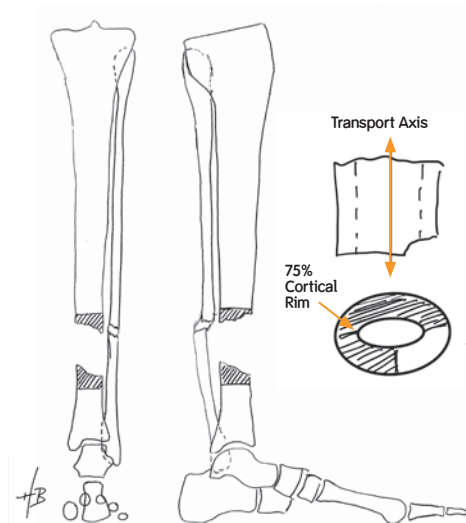
Care should be taken not to permanently deform the Cable. Pass a #2 nylon suture through the individual strands of metal Cable. Pull the suture to ensure that the nylon suture is in contact with the metal bead at the very end of the Cable, and allow the Cable to recoil to its natural state.

Repeat the same steps for the other end of the Cable. It is helpful to use different color sutures, for easy identification.



Bone Preparation

The fracture site is debrided in the standard fashion until only healthy bleeding bone is present. The ends of the bone are examined and the location in the bone segment at which there is at least 75% of the cortical circumference is intact is identified. The bone ends are prepared at that location with a low energy saw and constant iced saline irrigation. The bone cut is made orthogonal to the long axis of the bone segment and punctate bleeding must be present.



Passing the Cable in the Transport Segment

At least 10mm from the docking end of the transport segment, use a 4.8mm Drill to create a transverse hole through the mid-equator of the medullary canal of the transport segment.



Figure 1

Pass a Hewson Suture Retriever (71111579) through the drilled hole. (Fig 2) Pull #2 Nylon suture loop through the hole using the Hewson. (Fig 3).

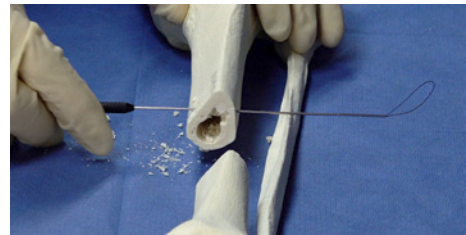


Figure 2



Figure 3

Use the suture loop to pull the Leading End (LE) of the Cable through the hole. (Fig 4)

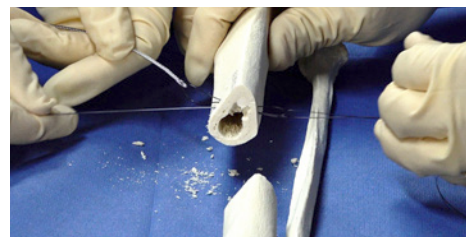


Figure 4

Pull the suture loop from the lateral side and bring the Cable all the way through until the suture loop on the Trailing End (TE) is on the medial face of the bone. Advance the Cable all the way until the Trailing End (TE) is in the canal. (Fig 5)



Figure 5

Passing the Cable in the Transport Segment *continued*

Use a tonsil clamp to pull the Cable into the defect. (Fig 6)

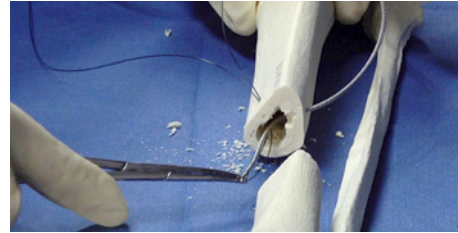


Figure 6

Pass the Hewson through the hole once again, followed by the suture loop, so that it exits medially. (Fig 7)



Figure 7

Use the suture loop to bring the Leading End (LE) of the Cable back into the defect. (Fig 8)

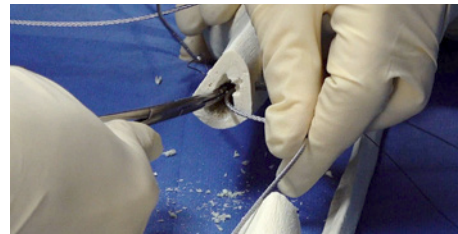


Figure 8

Pull the Cable taut and determine which tail corresponds to the medial cortex of the transport segment and which tail corresponds to the lateral cortex of the transport segment. This relationship should be preserved when entering the medullary canal of the docking segment (i.e. do not cross the Cables). (Fig 9 & 10)

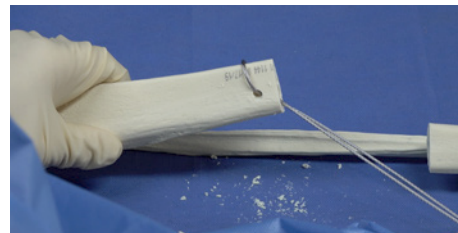


Figure 9



Figure 10

Passing the Cable through the Docking Segment

At least 10mm from the docking surface of the docking segment is optimal, especially when using a screw as a fulcrum, use a 4.8mm Drill to create a sagittal plane hole and leave the Drill in place (Fig 11).

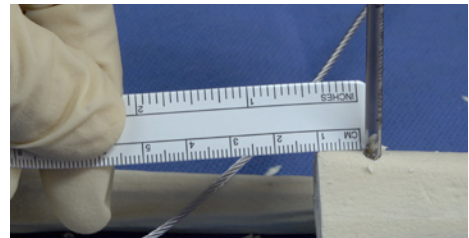


Figure 11

Opposite from the defect area and a few millimeters distal to the fulcrum Drill or Half Pin, drill a 4.8mm transverse hole through the docking segment, orthogonal to the shaft from medial to lateral. This hole should pass through the middle of the medullary canal of the docking segment. (Fig 12 & 13)

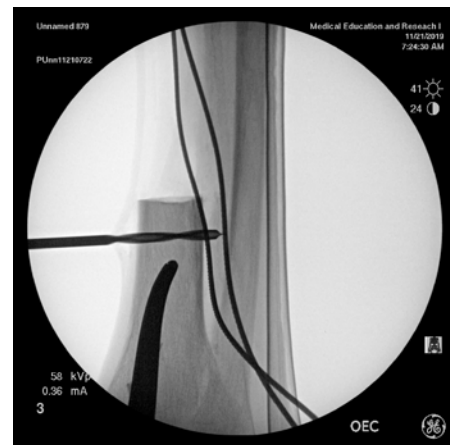


Figure 12 - Lateral image



Figure 13

Passing the Cable through the Docking Segment *continued*

Remove the sagittal plane (A-P) Drill. Use a HEWSON[®] Suture Retriever (71111579) to pass a suture loop through the transverse hole in the docking segment.

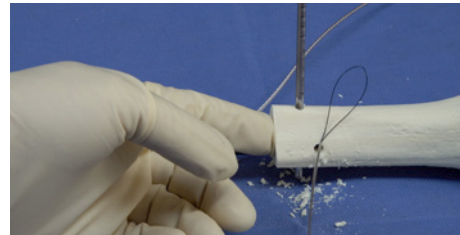


Figure 14

Bring this suture loop into the defect area, using a tonsil clamp. (Fig 14 & 15)

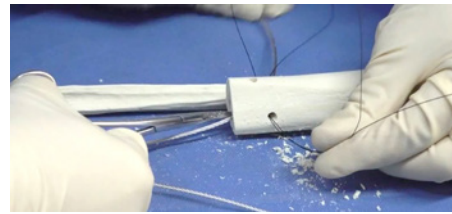
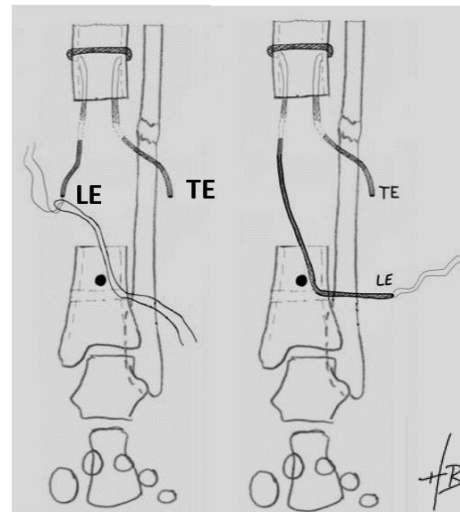


Figure 15



Use the suture loop to bring the #2 nylon suture and LE of the Cable into the canal of the docking segment and out through the lateral cortex of the docking segment. (Fig 16)

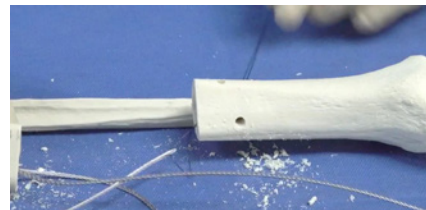


Figure 16

Note that the side of the Cable exiting the medial portion of the transport segment will exit the lateral side of the docking segment. (Fig 17) Repeat the sequence of suture shuttling to bring the other end of the Cable into the docking segment, exiting the medial cortex.

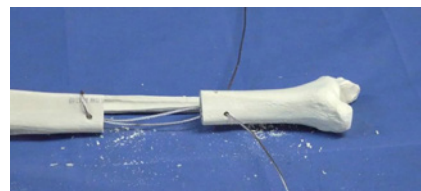
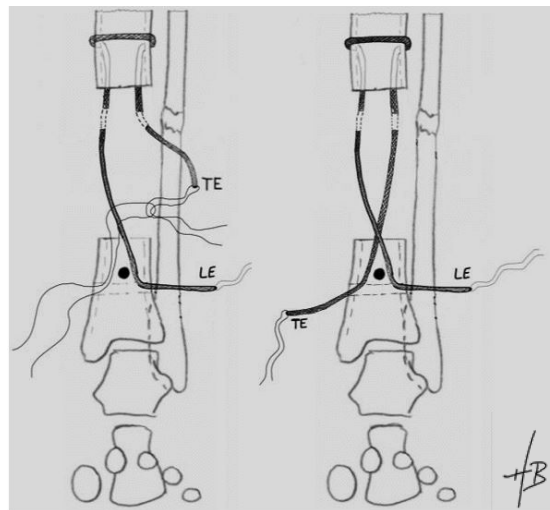
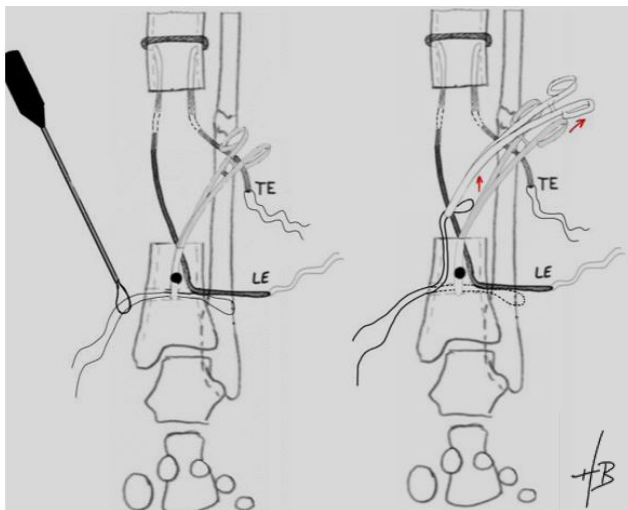


Figure 17



Passing the Cable through the Docking Segment *continued*

Advance a 6.0mm HA Coated Half Pin into the anterior cortex of the previously drilled sagittal plane hole for the fulcrum Half Pin.(Fig 18)

A 5.0mm TRIGEN® Screw also works well as a fulcrum pin, though it cannot then be attached to the frame.

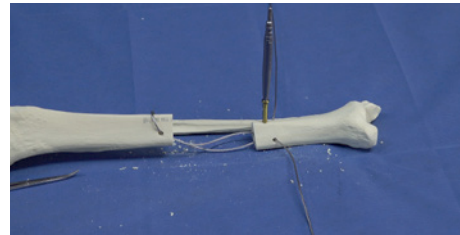


Figure 18

Slide a disposable Frazier suction tip over each end of the Cable. Insert the distal end into each side of the drilled transverse hole. This helps to direct the Cable around the fulcrum pin. Advance the Half Pin or Screw to achieve a bi-cortical A-P position. (Fig 19)

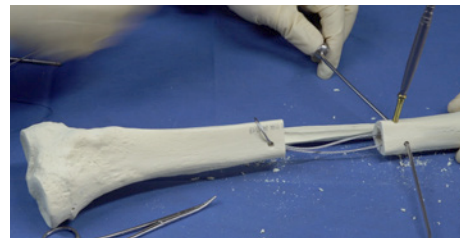


Figure 19

If using a Half Pin as the fulcrum, a portion of the frame must be advanced onto the limb prior to placement of this Half Pin. This tip will be discussed in Section 2.

Using fluoroscopy, confirm that both ends of the Cable wrap around the correct side of the fulcrum Half Pin. (Fig 20)

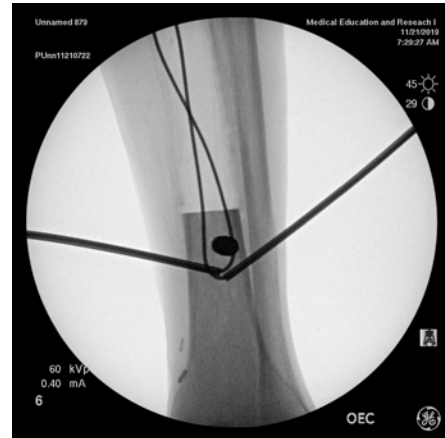


Figure 20

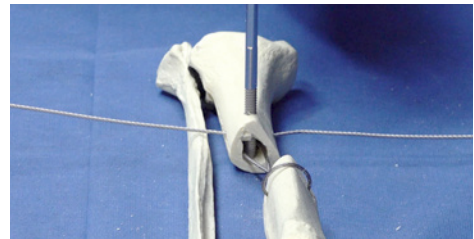


Figure 21 showing Half Pin used as fulcrum

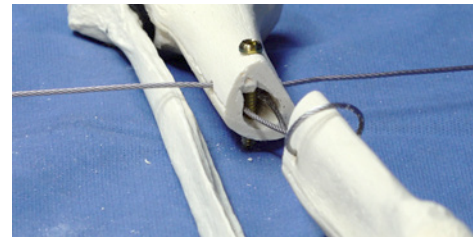


Figure 22 showing TriGen 5.0mm Screw used as fulcrum

Part 2: Frame assembly considerations

A minimum of three Rings are used for bifocal (one corticotomy) bone transport in the tibia. For trifocal transports (two corticotomies) at least four Rings are recommended. Four Rings are also recommended for any case in which conversion to internal fixation is planned.

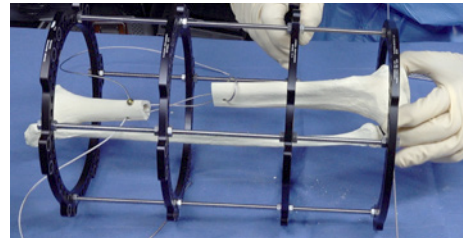


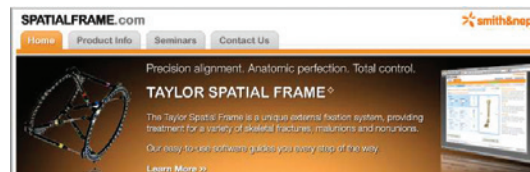
Figure 23

TAYLOR SPATIAL FRAME® (TSF) Rings are typically chosen over ILIZAROV™ Rings for several reasons. First, TSF Rings are thicker and more stable than ILIZAROV Rings, so fewer Rings are needed to obtain needed stability.

Another advantage of TSF Rings is that the outer holes on the tabs of one size Ring will line up with the inner holes of the next size Ring, which allows the surgeon to use larger Rings around the calf muscle and smaller Rings near the ankle.



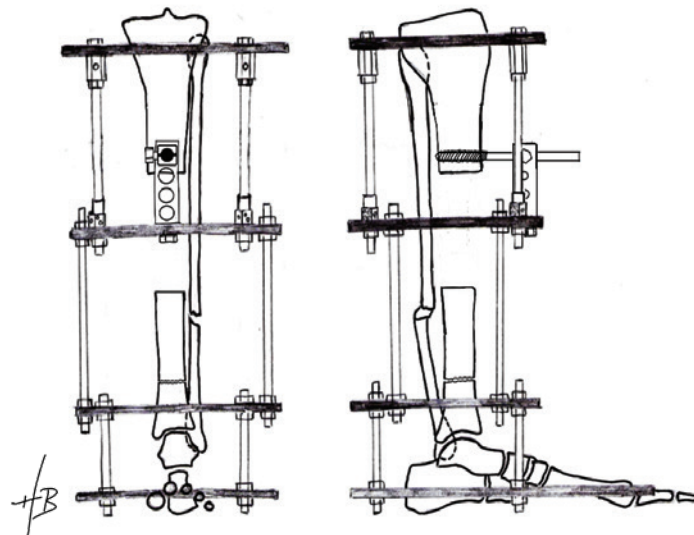
The use of TSF Rings also allow for in-clinic conversion to TSF Struts, should errors in alignment reveal themselves during the transport. Software-assisted (www.spatialframe.com) docking can be pursued once Struts are placed between Rings.



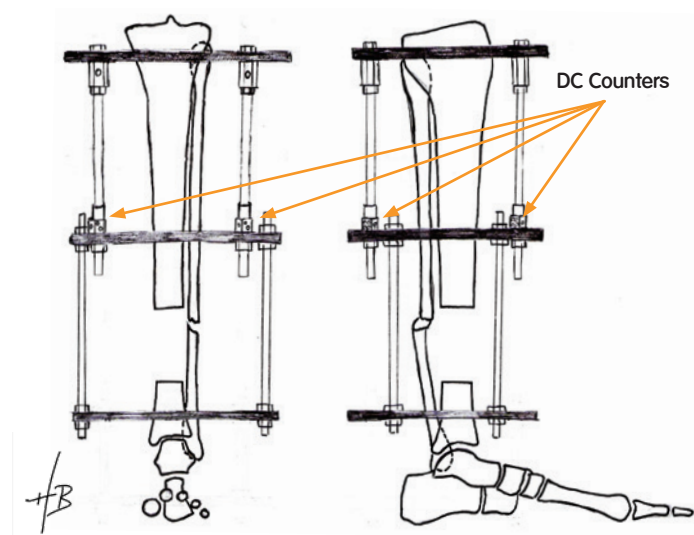
As with traditional circular frames for bone transport, the distance between the proximal and distal most Rings will be largely determined by the overall length of the limb. In situations where shortening has occurred, an intact, contralateral limb can be used to establish original limb length.

Unlike traditional circular frames for bone transport, the interior Ring(s) (those in between the proximal and distal most Rings), DO NOT MOVE during the transport process, and therefore do not drag half pins or wires through the skin.

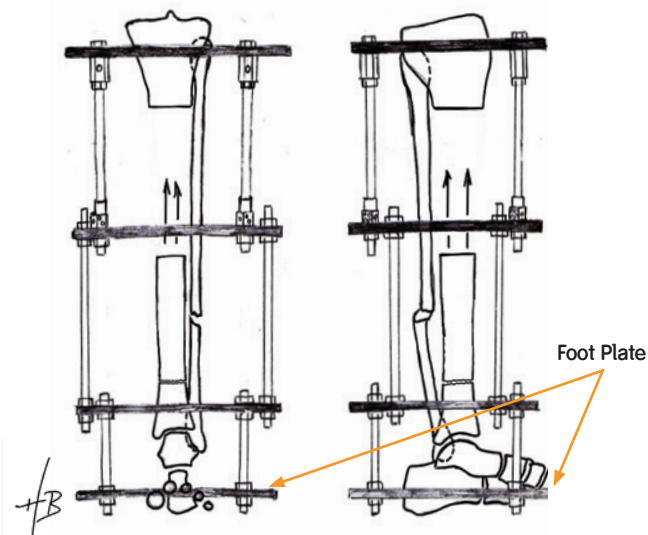
The placement of the interior Ring(s) is determined based primarily on frame stability needs. Sometimes, the location of the interior Rings is determined by the need to place Rancho Cubes for the fulcrum Half Pin.



DC Counters (103302) can be used as the Nuts around the interior Rings of the frame, in cases where there is Limb Length Discrepancy (LLD) in addition to the bone defect. Telescopic Rods (aka Clickers) could also be used for this purpose.

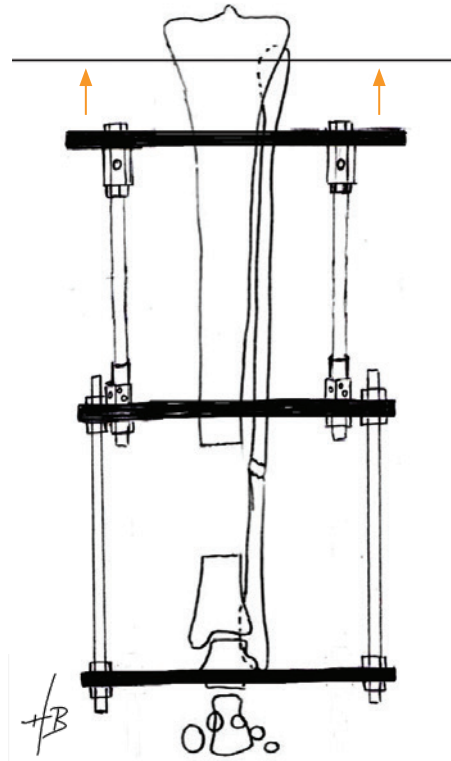


In distal-to-proximal transports (>4cm) in the tibia, other authors² have recommended the prophylactic use of a Foot Ring to span the ankle and help prevent the development of an equinus contracture.



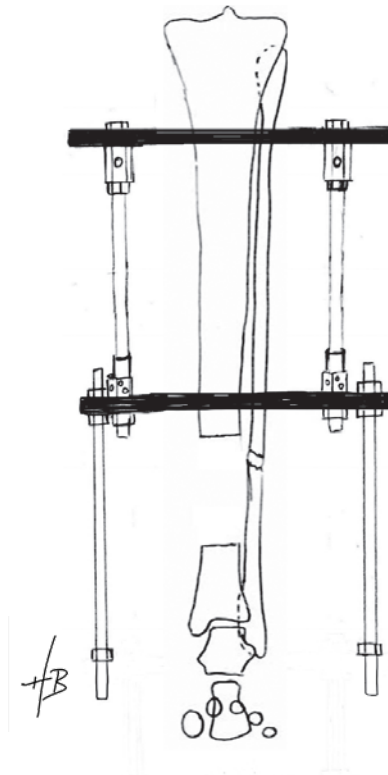
Part 3: Frame attachment, fixation, and Cable attachment

A reference Wire is placed perpendicular to the shaft of the tibia, or 3° from the joint line (MPTA= 87° ; range 85° - 90°) at the level of the fibular head. This Wire should be at least 15mm distal to the articular surface in order to remain out of the capsule and therefore extra-articular³.



If an anterior-posterior directed Half Pin is used as the fulcrum in the distal bone segment, then a portion of the frame should be advanced proximal to this location prior to placement of this Half Pin. The distal most Ring of the frame can be added after the placement of the A-P Half Pin.

A stable frame is constructed by placing Half Pins and ILIZAROV™ Wires according to Hutson⁴ and Catagni³.



The Pulley construct is assembled using a 30mm Bolt (103202), a Post (male or female; 2 Hole to 4 Hole), a spacing Washer (102700), a Pulley, a second spacing Washer, and a Nylon Nut (103301). Tighten the Nylon Nut then back it off 1/4 turn.

The diameter of the Pulley and the height of the Post are selected based on the distance between where the Cable exits the docking site and the associated Ring where it will be attached. Ideally, the Cable will exit the skin and remain both parallel to the associated Ring AND tangential to the chosen Pulley.

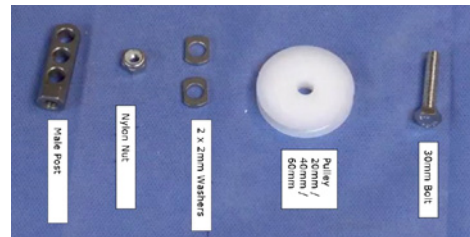


Figure 24



Figure 25

Part 3: Frame attachment, fixation, and Cable attachment *continued*

The Transport Struts are used in pairs to act as the motor that advances the Cable. The Transport Strut is connected to the Ring using a Connection Bolt.

Transport Struts should be positioned such that the scale faces anteriorly, and is easy for the patient to read.



Alternatively, the Transport Strut can be connected to an assembly of a Rancho Cube and Plate, to raise the height and increase the travel distance as well as to facilitate clearance from impingement.

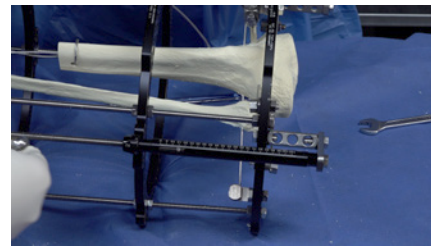


Figure 26

There are two strategies for securing the Cable to the Transport Strut.

Option 1

This method has the advantage of protecting the integrity of the Cable. Connect a Nut (103300) and Female Hinge (101700) to the Slotted Threaded Rod end of the Transport Strut. Secure the Cable in a Slotted Washer (102600) and Connection Bolt against the Hinge. The female hinge is oriented in a way that will allow it to pass freely by the Rings during the transport.

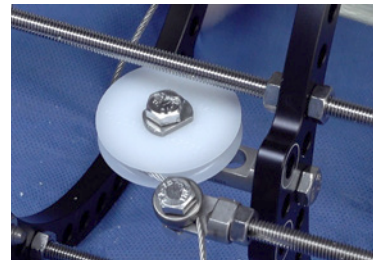


Figure 27

Option 2

This method is the lowest profile and requires the least assembly, but has the potential to crush the Cable and if advancement of the cable is necessary can expose sharp metal fibers. Thread a Nut (103300) on to the Slotted Threaded Rod and a Nut on to the Cable. Align the Cable in the slot and tighten the Nuts against each other.

Part 4: Corticotomy, Rate and Rhythm considerations

Like all other limb lengthening and reconstruction techniques utilizing the ILIZAROV™ method, the transport segment is separated from the intact bone using a low energy method. The gamut of these methods has been described by previous authors⁵.

This author prefers the method of multiple drill holes, popularized by De Bastiani⁶ and uses a $\varnothing 3.8\text{mm}$ drill bit to make the multiple passes. ILIZAROV™ osteotomes, along with a wrench are used to complete the corticotomy.

Sometimes, a Half Pin is temporarily placed into the transport segment. This Half Pin can be used to apply rotation to the free floating transport segment, ensuring that the corticotomy is complete.

Distraction at each corticotomy site is initiated at 1mm/day, following an appropriate latency period. If turning of the motor assembly gets very difficult from rapidly maturing regenerate, the author will typically have the patient increase the rate of each motor by 1/4mm each day.

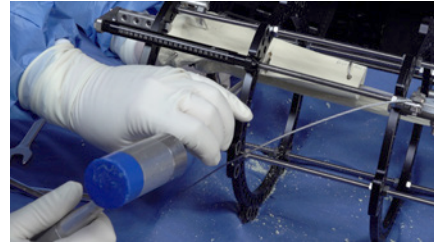


Figure 28

Part 5: Case example

Courtesy of Dr. Stephen Quinnan

Presentation:

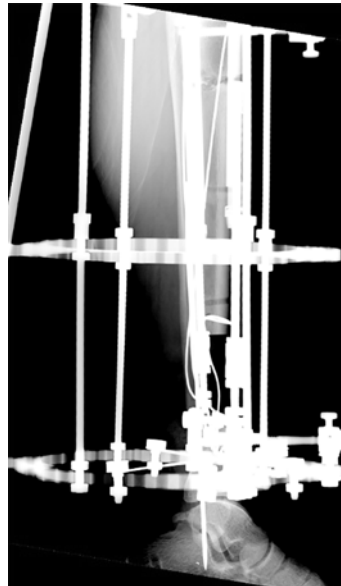
Thirty-year-old male presents with bi-lateral open tibial fractures after a motor-cycle accident. Image shows 3B fracture on the right side.

JetX unilateral fixator is applied to span the fracture and hold the limb out to length. Infection control strategies are employed at the open fracture site. The patient is transferred to a Limb Reconstruction unit.



Application of ILIZAROV™ with Balanced Cable Transport frame.

The fixator is constructed with three TSF® rings and Threaded Rods. Proximal and distal fixation blocks each have three Wires and a sagittal plane Half Pin. Effort is made to avoid the future nail path with frame fixation components. An intramedullary Wire is inserted in the fibula.



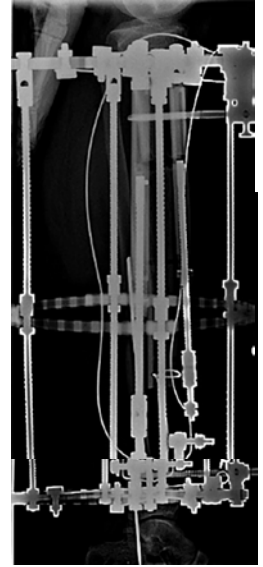
Progression of Transport at 1mm/day

2 weeks:

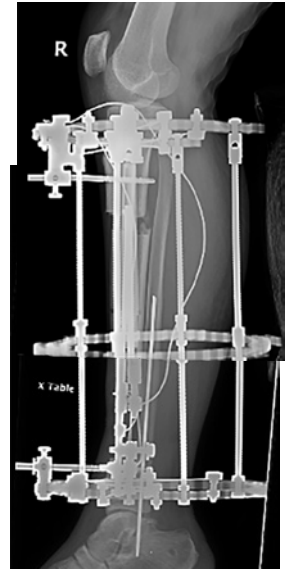
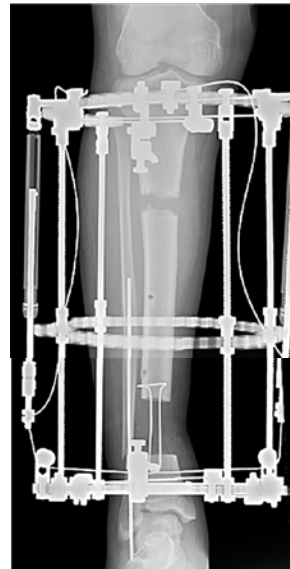
Anteroposterior view



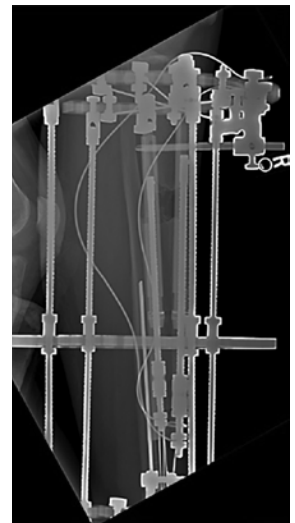
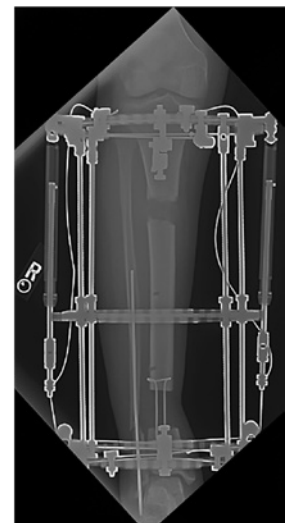
Lateral view



4 weeks:

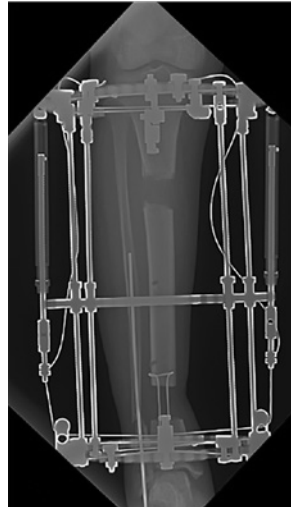


6 weeks:

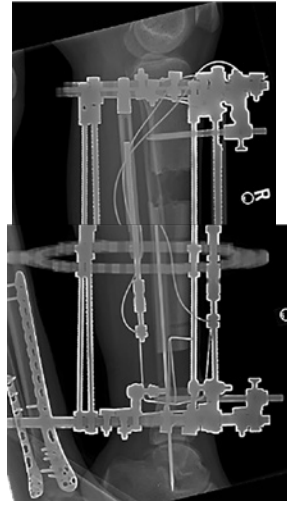


7 weeks:

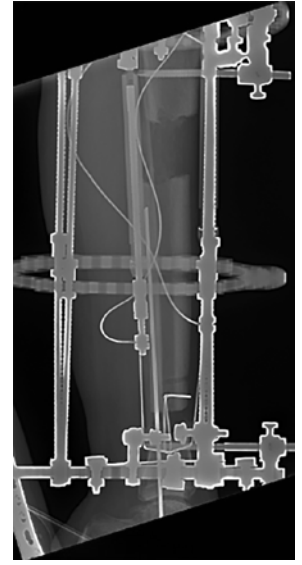
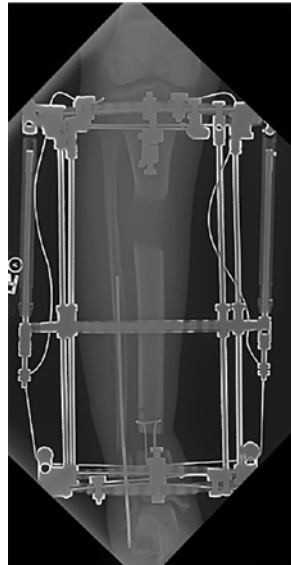
Anteroposterior view



Lateral view

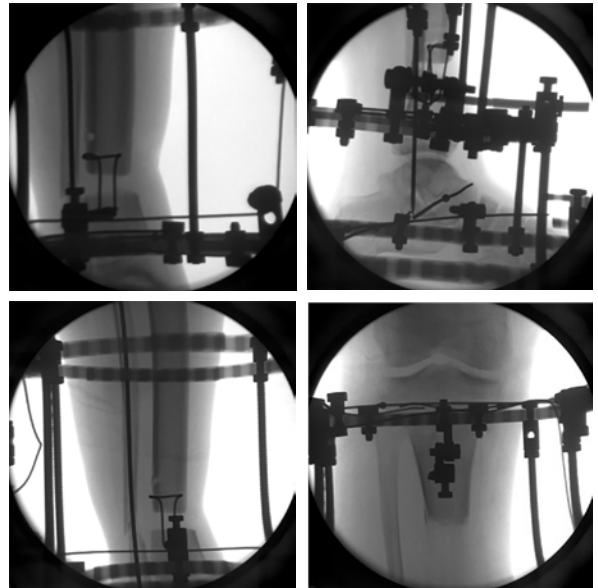


10 weeks:

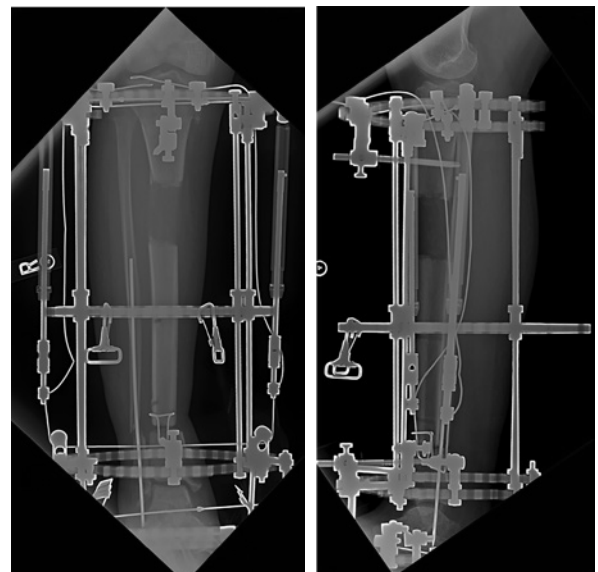


Application of Foot Ring and Removal of the Distal Tibial Wires

Eleven weeks from day of injury, and two weeks before docking, return to the operating room for addition of a Foot Ring and removal of the distal tibial Wires to prepare for conversion to intramedullary fixation. This is not routinely necessary, but is sometimes helpful with very short distal segments. This extra step allows removal of potentially contaminated pin pathways prior to nailing and also simplifies the nailing.



Transport complete at 3 months



Transport and then Nailing (TATN)

Three months and five days from time of injury, IM Nailing with an antibiotic cement-coated nail is performed and the frame is removed. It is important to secure the transported segment and prevent rebound.¹

See Quinnan & Lawrie JOT 2017 for strategies.



Anteroposterior view

Lateral view

Sequence showing progression to healing of docking site and regenerate.

3.5 months:



4.5 months:



Transport and then Nailing (TATN)

continued

Anteroposterior view

Lateral view

5.5 months:



6 months:



Final images at 8.5 months:



Part 6: Removal of Circular Frame

All components can be loosened with a pair of 10mm x 13mm Wrenches (L202002).

Set Screw removal requires 3mm Hex Driver (112719)

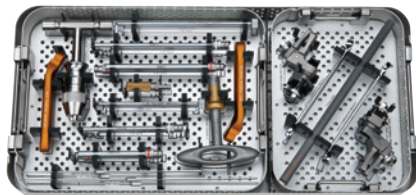
Wires should be cut close to the skin and pulled through using Wire Cutters (7107-0344). Always pull Olive Wires from the side with the olive, indicated by the black lines.

Pins can be reversed with a Universal Chuck T-Handle Driver (7117-0183).

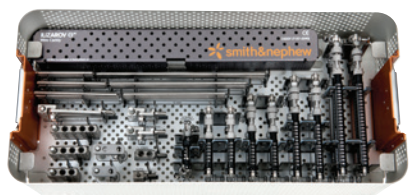
All External Fixation components are single use and should be disposed of in line with local biohazardous waste policy.

Part 7: TAYLOR SPATIAL FRAME[◊] Instruments and Implants

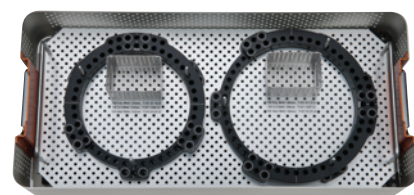
Instrument Tray



Hardware Tray



Ring Tray



71970663*

ILIZAROV Pulley 20mm



71970659*

ILIZAROV Pulley 40mm



71970660*

ILIZAROV Pulley 60mm



71970661*

ILIZAROV Cable ϕ 1.8mm x 1200mm



71935755

Transport Strut Long with 105mm stroke

71935756

Transport Strut Medium with 50mm stroke



*Packaged non-sterile. Immediate Use Steam Sterilization (IUSS) or routine sterilization instructions according to 71381340 should be followed prior to use.

103302 4 point Distraction-Compression Counter Square head



7111579 Hewson Suture Retriever Sterile Box of 6



OrthoSpecialties Drill Guide Semi-Extended Offset
OrthoSpecialties Meta Anterior Drop for Offset Guide



110311 Osteotome Straight 6.3mm

110313 Osteotome Straight 12.7mm

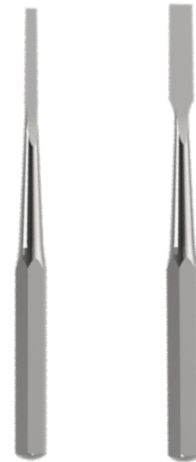
110315 Osteotome Straight 19.0mm

110316 Osteotome Straight 22.2mm

110317 Osteotome Straight 25.4mm

110319 Osteotome Straight 31.7mm

110308 Osteotome Case



71075903 Osteotome Wrench



111416 Combi Mallet



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