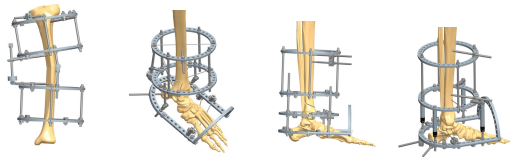
WASTON®



GENERAL PRINCIPLES: LIMB LENGTHENING AND DEFORMITY CORRECTION WITH WASTON TK-RINGRING FIXATION SYSTEM

INDICATIONS FOR USE

The TK-Ring system is intended for limb lengthening by metaphyseal or epiphyseal distractions, fixation of open and closed fractures, treatment of non-union or pseudoarthrosis of long bones and correction of bony or soft tissue defects or deformities.

Warnings

Particular care should be taken that wires and half pins do not enter the joints or damage the growth plates in children.

Precautions

Use the TK-Ring system for specific patients is at the discretion of the treating surgeon. In general, application of a circular external fixator and post-operative management require appreciable experience and skill in the technique. In addition, building a specific frame to treat an individual case is of fundamental importance to the successful outcome of the procedure, and beyond the scope of this discussion. The reader is referred to manuals, textbooks, and skills laboratories for appropriate training in all aspects of the

TK-RING EXTERNAL SUPPORTS

TK-Ring external supports are made from high-strength, anodized aluminum. They are offered in a variety of shapes and sizes to allow customizable frame constructs based upon particular clinical conditions, but have similar design features.All full rings, half rings, 5/8 rings, foot plates and double row foot plates have quadrant markings to simplify frame assembly. All external supports accept 6mm threaded components.

Figure 1

Full Rings

TK-Ring full rings are the basic building blocks of the system. They are offered in 13 different sizes of internal diameters ranging from 45 mm (Pediatric) to 240mm (Figure 1).

Half Rings

Half rings come in twelve different sizes, ranging from 80mm to 240mm (Figure 2). The unique connection hole is a pocketed fit for positive location and stability. This pocketed fit provides a secure junction without losing fixation holes on either side of the connection hole. Half rings can be used alone, joined together to form a full ring, or connected to other external supports (i.e. foot plate extensions) depending on local anatomical requirements. Figure 2B is a simple Half ring which can be connected with Foot Ring (Figure 5B)

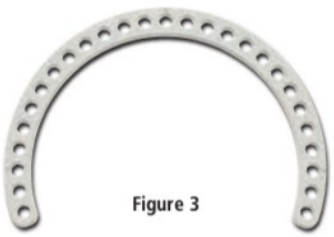


Figure 3

5/8 Rings

5/8 rings are offered in 12 sizes, ranging from 80mm to 240mm **(Figure 3).** These partial rings can be useful at the joints to extend the range of motion possible while in the fixator.

Figure 4

Italian Arches

Arches are manufactured in two sizes, a 90mm radius arch with holes covering a 95° span and 120mm radius arch with holes covering an 85° span **(Figure 4).** Arches are commonly used to secure half pins in the proximal femur and proximal humerus.

Figure 5A

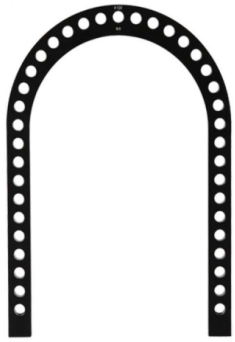


Figure 5B

Foot Plates

A foot plate is a modified half ring with elongated ends.They are available in 12 sizes, ranging from 80mm to 240mm,(**Figure 5A**). The pocketed fit connection holes at the ends of the foot plate can be used to connect foot plate extensions, oranother foot plate, to create a customized foot support assembly for any shape and size of foot. (Figure 5B) is a simple feet ring with thread hole ends ,used in conjunction with a half rings (Figure 2B) vertically.

Figure 6

Foot Plate Extensions

Foot plate extensions are offered in two lengths, three hole and five hole **(Figure 6).** One end has a pocketed fit connection hole, while the opposite end is tapped to accept a standard 6mm threaded element. A pair of foot plate extensions, used in conjunction with a foot plate and half ring, provide the ability to build a custom, three dimensional foot support assembly to accommodate virtually any shape and size of foot.

Double Row Foot Plate

Figure 7

The double row foot plate is an enhanced version of the standard foot plate (Figure 7). The enhancements include a wider base, a second row of fixation holes, and a longer side mounting area for additional elements. The wider and longer fixation mounting area provides greater versatility for wire fixation and connection element attachment. The ends are tapped to accept a standard 6mm threaded element. It is available in three sizes, ranging from 150mm to 200mm.

TK-RING ASSEMBLY ELEMENTS

Figure 9

All TK-Ring assembly elements are made from stainless steel. Threaded elements have a standard M6 thread, and can be adjusted using a 10mm wrench.

Figure 10A Figure 10B

Bolts
TK bolts are offered in three lengths; 12mm, 15mm ,25mm,30mm (Figure 9).

Nuts
The TK set offers two types of nuts. The standard nut is the primary assembly element used (Figure 10A), but the extended nut is useful for tightening elements placed in adjacent holes (Figure 10B).

Figure 11

Spacing Washer

Washers contained in the TK set are 2mm thick (Figure 11). TK WIRES, HALF PINS,

TK WIRES, HALF PINS, AND FIXATION ELEMENTS

General Principles of Segmental Fixation

Figure 12

Figure 13

The fundamental mechanical principle of the TK system is to achieve stable transcutaneous segmental fixation of bone to permit stabilization or manipulation of those segments as required for the condition under treatment.
The basic fixation “unit” for a bone segment, as originally described by Ilizarov, is one ring with two crossed, tensioned wires. The ring should be perpendicular to the long axis of the bone segment, and ideally the limb is centered within the ring.

Wires

2.0 mm diameter TK wires are available in two types; smooth (Figure 12) and beaded (or stopper) wires (Figure 13). Beaded wires provide a stop at the bone interface.
Beaded wires serve two main purposes:

To enhance stability of fixation by preventing undesirable motion (i.e. bone translation when the wires are placed at a narrow crossing angle)

To move a bone segment in a desired direction (i.e. fracture reduction or segment compression)

Both wire styles have a bayonet-shaped, eccentric tip which efficiently drills through both

Figure 14

Half Pins

TK half pins are offered in 4, 5, and 6mm diameters (Figure 14), They are self-drilling, self-tapping. Also available sterile and with Hydroxyapatite coating. (Please noted that the different diameter half pin has different coulping , relative T-Wrench need to be prepared before the surgery.)

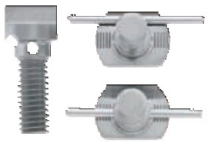


Figure 15

Universal Wire Fixation Bolt

The TK-Ring universal wire fixation bolt **(Figure 15)** functions as either a slotted wire fixation bolt or a cannulated wire fixation bolt. The 10mm bolt head is slotted and the bolt neck is cannulated to accept a 1.8mm wire. An additional design feature is the horizontal grooves on the slot and base of the head which enhance the gripping force on the wire.

Figure 16

Slotted Washer

The TK-Ring slotted washer is an oblique, hardened steel washer with a serrated slot to accept a 2.0 mm wire. This washer may be seated over any threaded component to convert it to a slotted fix- ation device **(Figure 16)** and used to capture the wire in positions when a wire fixation bolt cannot be used. The serrated slot is designed to increase the gripping force of this fixation element.

Figure 17A

Figure 17B

Universal Half Pin Fixation Bolt

The TK-Ring universal half pin fixation bolt **(Figure 17A)** has an oblique slotted opening that provides secure fixation for 6mm diameter half pins. The half open desigen allows the Bolt can be assembled on the ring without pass though the half pins before insertion.
The TK-Ring universal half pin fixation bolt **(Figure 17B)** has a sliding collar fitted over a teardrop shaped opening that provides secure fixation for 4,5, and 6mm diameter half pins. The sliding collar has a serrated base and scalloped top to enhance the gripping force on the half pin and external support.

Figure 18

Supporting Cube

TK-Ring supporting Cube (Figure 18) are available in five sizes, ranging from 1 hole to 5 holes. The holes on the cube have standard female threaded base, allowing the half pins to be secured on the cube locked by a 12mm bolt.

Figure 19

Male Plate

TK-Ring Male Plate (Figure 19) are available in three sizes, ranging from 2 hole to 4 holes. The posts have a standard Male threaded post, allowing them to be secured to an

Figure 20

Female Plate

TK-Ring Female Plate **(Figure 20)** are available in three sizes, ranging from 2 hole to 4 holes. The posts have a standard Female threaded post, allowing them to be secured to an external support by a 12mm bolt.

Figure 21

TK-Ring Posts

TK-Ring posts **(Figure 21)** are available in five sizes, ranging from 1 hole to 5 holes. The posts have a standard female threaded base, allowing them to be secured to an external support by a 12mm bolt. The serrations on the base prevent undesirable rotation after tightening.

BASIC PRINCIPLES OF WIRE INSERTION, TENSIONING AND FIXATION

Wire Insertion
Insertion of an individual wire involves the following steps:

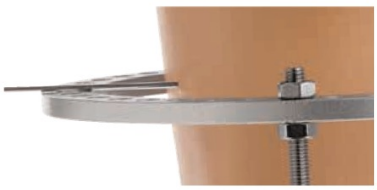


Figure 22

1. The wire is placed on the surface of the ring and pushed through the skin at the desired level and orientation to the bone surface **(Figure 22).** Many considerations come into play when determining this orientation, including cross-sectional anatomy, location of the second wire, and the long axis of the bone segment. The wire should be passed straight through the skin along the desired axis of the wire. Fluoroscopy may be used to confirm proper orientation of the ring and the wire to the limb. The appropriate size ring, centered on the limb, or an entire pre-constructed frame may serve as a guide to proper orientation.

Figure 23

2. Insert the wire through the bone using a slow drilling speed. Keep the wire straight by avoiding excessive pressure. Efforts should be made to keep the wire cool during insertion such as interrupted incremental advancement, using gauze soaked in saline to stabilize the wire, or setting a saline drip on the wire itself.

Figure 24

3. Once the wire exits the bone, drill or tap with a hammer to the opposite skin edge. The skin on the opposite side of the limb should be stabilized over the wire prior to the wire exiting the skin.

4. Once the wire has exited, check the skin to see that there is no tension around the wire. If tension is present, withdraw the wire beneath the skin surface and then re-advance.Once satisfied, continue to advance the wire several centimeters beyond the ring to allow fixation and tensioning (Figure 23).

Figure 25

5. If a stopper wire is used, make a small stab incision along the wire track **(Figure 24)** to allow the bead to pass through the skin. Stopper wires are advanced until the bead contacts the bone cortex. This can be accomplished by pushing the wire with a power drill or pulling the opposite end of the wire with pliers **(Figure 25).**

Securing the Wire
Secure both ends of the wire to the external support using wire fixation bolts. This must be done with a minimal amount of wire bending.

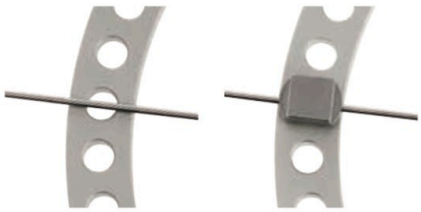


Figure 26

The wire may bisect a ring hole. In such cases, use the cannulated feature of the wire fixation bolt **(Figure 26).** Slide the bolt over the wire, insert into the proper hole, and secure it to the ring using a 10mm nut. The head of the bolt must not be rotated relative to the axis of the wire to ensure that the wire remains straight. Use a 10mm wrench to hold the head of the bolt while tightening the nut.

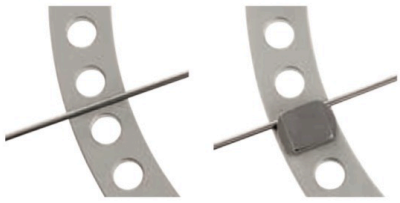


Figure 27

The wire may be at the edge of a hole, or between two holes. Use the slotted feature of the wire fixation bolt in these situations **(Figure 27).**

The wire may be on the surface of the ring, or at a distance away from the plane of the ring. This occurs when the wire is either inserted parallel, but at a fixed distance away from the plane of the ring. This commonly occurs because the axis of the wire is slightly non-perpendicular to the bone segment axis. In these situations, fill the space between the ring and the wire with spacing washers **(Figure 28)**, or use a post (Figure 29), to avoid wire bending. Place an appropriate number of washers onto the fixation element prior to wire fixation. Up to three washers may normally be used, depending on the thickness of the ring. A post should be used if more than three washers are required.

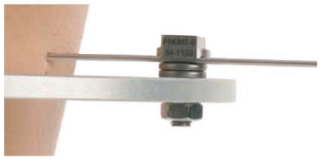
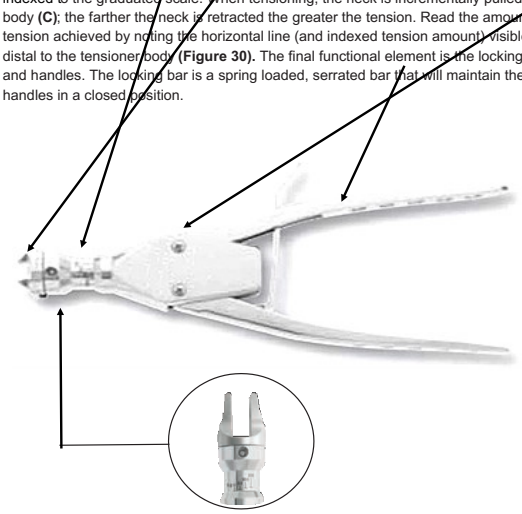


Figure 28

Figure 29

TK-Ring Wire Tensioner
The TK-Ring wire tensioner is a spring-loaded, forceps style instrument consisting of four functional elements. The tensioner head **(A)** has a unique sliding adapter that will allow the head to capture the wire fixation bolt when used in both the cannulated and slotted configurations. The neck **(B)** displays the wire tension scale, which is graduated from 50Kg to 130Kg. The scale has lines oriented horizontally to the axis of the neck, which are indexed to the graduated scale. When tensioning, the neck is incrementally pulled into the body **(C)**; the farther the neck is retracted the greater the tension. Read the amount of tension achieved by noting the horizontal line (and indexed tension amount) visible just distal to the tensioner body **(Figure 30).** The final functional element is the locking bar **(D)** and handles. The locking bar is a spring loaded, serrated bar that will maintain the handles in a closed position.



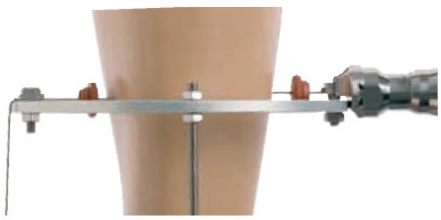


Figure 31

Tensioning the Wire
Tighten a wire fixation bolt on the wire to the ring on the side away from where the tension will be applied. Bend the end of the wire 90° to the plane of the ring **(Figure 31).** This provides a quick visual clue that tension will be drawn on the opposite side.

Tensioning the wire involves drawing the wire against its fixed end. The level of tension applied varies with the clinical circumstances and individual preference. Typically, forces of between 100Kg and 130Kg are used.

Steps to tension a wire using the TK-Ring wire tensioner:

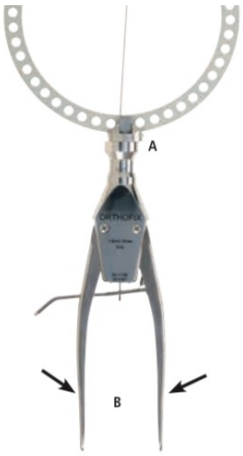


Figure 32

1. Fully open the handles and slide the tensioner over the wire. Ensure the tensioner head captures the wire fixation bolt, and is firmly against the external support (Figure 32A).

2. Squeeze the handles together until the desired amount of tension is generated. The wire tensioner locking bar will hold tension at a constant level (Figure 32B).

3. Securely tighten the nut on the wire fixation bolt.(Figure 33).

4. Release the wire tensioner by depressing the locking bar and fully opening the handles. This disengages the wire tensioner jaws, and will allow the tensioner to slide off the wire (Figure 34).

5. Cut the wire ends flush with the frame avoiding sharp edges. Alternatively, to avoid causing injury the ends of wires should be protected with special covers or bent at the ends as soon as they are tensioned.

Figure 33

Figure 34

Figure 35

The sequence of wire insertion and tensioning will vary depending on the specific nature of the disorder, frame application, and the surgeon's preference. In general, it is preferable to insert the most proximal and most distal wires, secure and center the apparatus to these wires, and then complete wire insertion and tensioning.

Simultaneously tensioning two wires on the same ring is advisable **(Figure 35)**, since sequential tensioning may alter the tension of the initially tensioned wire.

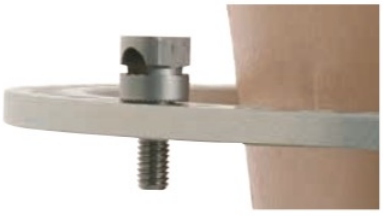


Figure 36

Figure 37

BASIC PRINCIPLES OF HALF PIN INSERTION AND FIXATION

Half Pin Insertion with Universal Half Pin Fixation Bolt

The basic principles of aligning a ring on the limb perpendicular to its long axis remain the same when half pins are used instead of or in conjunction with wires. Furthermore, the half pin should be fixed to the ring in a manner which prevents any torque between the half pin and the ring by properly orienting the half pin fixation bolt to both the half pin and the ring.

The use of half pins in place of wires, as well as their orientation and number are at the discretion of the surgeon based upon training, knowledge of anatomic safe zones, and surgical preference.

The following steps outline the recommended method of half pin insertion and fixation:

1. A half pin fixation bolt is inserted into an appropriate hole. The half pin fixation bolt acts as a guide for half pin insertion **(Figure 36).**

Figure 38

2. A K-wire is passed through the hole of the fixation bolt along the intended direction of the half pin insertion. Make a stab incision in the skin at this level **(Figure 37).**

3. Use scissors or hemostats to make a track through the soft tissues to the bone.

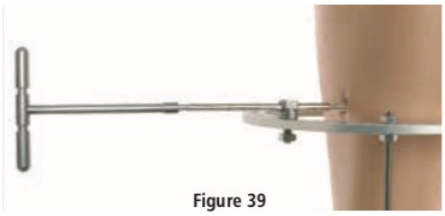


Figure 39

4. The desired half pin is inserted through the fixation bolt, the soft tissue track, and drilled into the first bony cortex **(Figure 38).** Insertion through the second cortex should be done manually using the T-wrench supplied in the set **(Figure 39).**

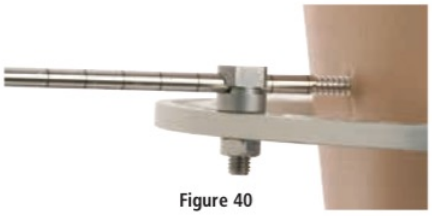


Figure 40

5. The half pin fixation bolt is then secured firmly to the external support with a nut **(Figure 40)**.

Plates

TK-Ring plates come in four lengths, ranging from 20mm to 50mm (Figure 55). One end of the plate is a threaded hole, with serrations for greater rotational stability. The other end is either a single 7mm hole, or a slot, for greater adjustability Plates provide the surgeon the ability to connect external supports in a parallel, non-aligned (short offset) configuration

Oblique Support

An oblique support provides the ability to create a parallel,non-aligned (large offset) ring block ,The oblique sup- port is useful for connecting arches or partial rings to full rings, especially at anatomic sites like the proximal humerus or proximal femur. One end of the oblique support has a threaded socket, while the other is a standard diameter hole.

TK-RING HINGES AND ANGULAR DISTRACTORS

TK-Ring hinges and angular distractors consist of internal and external components, which are designed to interface with each other to provide a constantly self-adjusting, stable angular correction system. In addition, the angular distractor is simple for the patient to operate, reducing the opportunity for error and patient discomfort.

There are two types of pre-assembled hinges used for angular deformity correction; the inline and outboard hinges. Both consist of a hinge base, a rotational insert, and a 100mm elliptical profile threaded rod which is secured in the insert with a set screw.

Inline Hinge
The inline hinge has a threaded hole at the base to accept either a fixation bolt or threaded rod for proper hinge axis location. The end of the threaded rod is secured to a ring in the traditional fashion with nuts as required for a specific assembly.

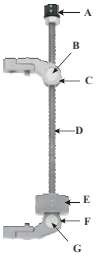
Outboard Hinge
The outboard hinge assembly is similar to the inline hinge, but the hinge base has a plate extension with a threaded hole to secure the hinge either directly to the ring with a 12mm bolt or at a distance from the ring by using washers or a spacer, A 20mm plate is connected to the end threaded rod as part of the assembly to facilitate fixation to the adjacent ring.

Additional Hinge Rods
Both inline and outboard hinges are assembled with 100mm elliptical profile threaded rods. Two additional sizes of threaded rods (60mm and 150mm) are available for hinge assemblies.They may be used in instances where a shorter or longer overall hinge length is desired.

To replace the elliptical profile threaded rod in the hinge assembly, the surgeon should loosen the set screw of the rotational insert, pull the threaded rod out, replace it with the desired rod by inserting the elliptical end of this rod in to the rotational insert, and then tightening the set screw again.

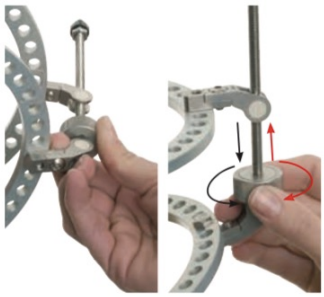
Hinge Extender

When the length of threaded rod used in the hinge exceeds 150mm, the TK-Ring hinge extender should be used to increase the length of the rod. The hinge extender may also be used to increase the overall rigidity of the frame structure



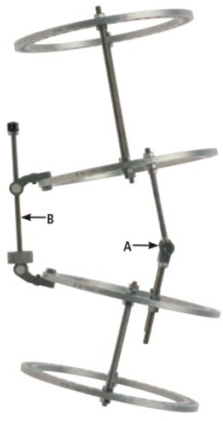
Angular Distractor

The TK-Ring angular distractor consists of two distractor brackets (C, F), a special threaded rod (D), and a locking compression/distraction wheel (E). The distractor brackets consist of two components which are held together with a set screw: the base and the arm. The bracket base has a threaded hole to secure the hinge either directly to the ring with a 12mm bolt or at a distance from the ring by using a spacer. Each distractor bracket arm has a plastic insert (B, G) to interface with the bracket and threaded rod.One of the distractor bracket inserts (G) functions as a rotational socket, which interfaces with the end of the threaded rod. The other distractor bracket (C) has a threaded plastic insert, which interfaces with the threads on the rod. Each distractor bracket is able to pivot around the plastic insert, allowing the angle between the rings to adjust automatically as the distance between brackets changes. Multi-planar adjustments between the rings will be achieved by attaching each distractor bracket arm to the ring .
A four-sided, 10mm nut (A) is fixed to the free end of the threaded rod. The dice markings on the nut provide a clear visual reference to monitor adjustments. The nut also provides an added safety measure by preventing the threaded rod from turning out of the bracket.



Compression/distraction wheel

The compression/distraction wheel is a two-piece mechanism, which is locked to the threaded rod. The compression- distraction wheel has an outer collar and a central locking core. The outer collar is spring loaded over the locking core. The locking core has a square hole, which fits over the base of the distractor bracket preventing the wheel from turning. When the outer core is retracted, the knob is free to rotate When the compression/distraction wheel is turned, the threaded rod rotates. When rotating, the rod end turns freely in the rotational socket, while the bracket with the threaded plastic insert is translated along the threaded rod



ANGULAR CORRECTION WITH TK-RING HINGES AND ANGULAR DISTRACTOR

Proper use of a circular external fixator to correct angular deformities requires advanced skill in the application of the frame to the deformed limb segment. Pre-operative planning is essential to the successful correction of these deformities. The following steps are required:

1. The x-rays must be analyzed by the surgeon to determine the apex of the angular deformity. Inline hinges will normally be used to correct deformities where the axis of rotation will be between the rings of the frame. In such cases, a frame would be constructed for each bone segment, connected by two hinges centered at the apex of the deformity and an angular distractor on the opposite side. If a simple opening wedge correction is desired, the hinge apex must be placed at the cortex of the bone on the convex side of the apex of the deformity. If lengthening is desired in addition to opening wedge correction, the hinges should be placed beyond the cortex at the level of the apex.

2. The frame should be pre-constructed to mimic the deformity with the appropriate size and number of rings. The TK-Ring hinges **(A)** and an angular distractor **(B)** are used to connect the non-parallel ring segments at the level of the deformity.

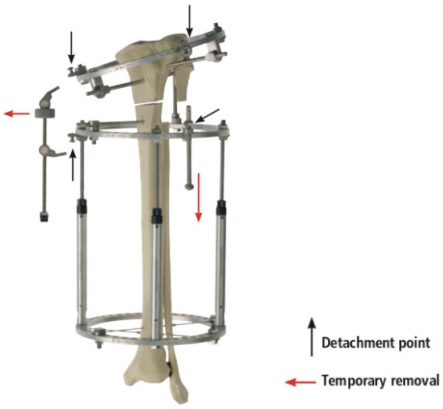
3. The pre-assembled frame should be checked on the patient’s limb to ensure proper sizing and deformity analysis.

4. The deformity is corrected as a result of the osteotomy and the gradual distraction by the TK-Ring angular distractor.

5. Most surgeons design the distraction process so that when the rings are brought into a parallel relationship, the deformity has been corrected.

Frequently, the proper hinge location for correcting some specific deformities is at the level of the rings on one segment, or even further removed from the space between ring segments. For example, many pediatric deformities, such as Blount's disease, have the apex of their deformity located at the growth plate. The outboard hinge, with its plate extension, allows for easy pre-operative frame assembly, which will properly correct these types of deformities.

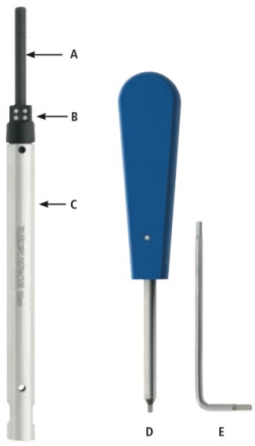
Pre-operative planning for correction of such deformities, including frame assembly, should be carried out as described previously. Proper location of the outboard hinge is dictated by the surgeon's evaluation of the deformity, the normal axis of the limb, and the amount of length desired. When a proper hinge location has been identified, the frame will be centered on the limb both proximally and distally.



Frame Disassembly for Osteotomy Access

To provide access to the limb and ensure completion of the osteotomy, the hinges and angular distractor need to be temporarily disassembled. The angular distractor is disassembled by loosening the bracket set screws and removing the distractor body. Hinge disassembly is achieved by loosening the set screw on the rotational insert and the nuts on the end of the threaded rod. Loosen the nuts securing the ends of the hinge rods from their position on an external support opposite end to allow them to retract.

After the osteotomy is completed, the elliptical profile ends of the threaded rods of the hinges are reinserted in the rotational in- serts, the set screws are tightened, and the ends of the threaded rods secured as they were before disassembly.The arms and bases of the angular distractor brackets are reassembled and the set screws tightened.



Post-Operative Adjustment

The threaded rods supplied with the TK-Ring system have a stan- dard pitch of 1mm. Thus, each 360° of rotation of the compres- sion/distraction wheel affects 1mm of distraction between the brackets. The actual amount of distraction required and the frequency are determined by the surgeon, based on the relationship of the hinges and angular distractor to the bone, and the quality of new bone formation within the distraction gap.

To operate the angular distractor the patient lifts the outer collar, rotates the compression/distraction wheel the desired amount, then allows the collar to spring back into a locked position.Once angular deformity correction is complete, the hinges and angular distractor may be removed by the surgeon and the rings connected with threaded rods or other appropriate connection components.

TK-RING LINEAR DISTRACTORS

Telescopic Linear Distractor

The TK-Ring telescopic linear distractor consists of an aluminum tube **(C)**, which acts as the platform for a threaded rod (A), and a square-sided plastic bushing (B) which fits onto the aluminum platform in manner such that it is able to turn freely on the aluminum tube. The threaded rod mates with the plastic bushing in a manner such that the rod moves relative to the aluminum tube when the plastic bushing is rotated. The threaded rod has a 1/8" (3.2mm) hexagonal socket cut in the exposed end for use with a standard 1/8" hexagonal wrench (D), 90° hexagonal wrench (E) to facilitate rod length adjustment or threaded rod exchange.

When making a rapid rod length adjustment, use caution not to bottom out the rod in the distractor base or extract the threaded rod from the plastic bushing. If the threaded rod is completely visible in the hole of the base, a shorter linear distractor should be used.

The linear distractor should be replaced with a longer size if the threaded rod has reached the level of the hole at the top of the tube.

Secure the linear distractor to the rings of the frame using a 12mm bolt at the base of the aluminum tube and nuts at the threaded rod.The four sided bushing is marked, similar to a dice, with 1, 2, 3, or 4 dots **(A).** To increase the overall length of the distractor, and thus provide distraction, turn the bushing in the direction of increasing numbers

(i.e. 1 to 2, 2 to 3, etc.) at the prescribed rate. To decrease the overall length of the distractor, thus providing compression, turn the bushing in the direction of decreasing numbers
(i.e. 4 to 3, 3 to 2, etc.) at the prescribed rate.

TK-Ring telescopic linear distractors are available in four sizes, re- quiring a minimal clearance of 70mm between rings and providing a maximum extension of up to 300mm

DISTRACTION AND COMPRESSION WITH THE TK-RING LINEAR DISTRACTORS

Limb Lengthening

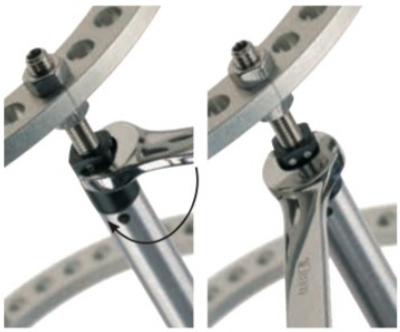
Lengthening of limb segments to generate new bone tissue may be indicated for one of many disorders including congenital limb deficiencies, bone loss due to fracture, tumor and infection.

The surgeon must carefully assess the patient and the x-rays to ensure appropriate indications for lengthening of a limb segment. The proper ring size should be selected based on soft tissue considerations for each patient as previously described.

The most common practice is to hold the ring segments together by using two telescopic linear distractors or threaded rods of the desired initial length attached directly anterior and posterior. This allows the distractors to serve as radiographic markers for proper alignment of the frame on the limb during surgery, while minimizing the chance that the distractor will occupy a ring hole required for wire or half pin fixation.

After all bone fixation elements (wires and/or half pins) have been inserted and tensioned, these two distractors are replaced by four appropriately spaced distractors as desired by the surgeon. Placement of four distractors at the 1:30, 4:30, 7:30, and 10:30 (clockface) positions minimizes the interference of the radio-opaque distractors with the distraction bone regenerate on the radiographs.

After the frame has been assembled and secured to the bone, the bone is cut at the level and fashion desired by the surgeon. To confirm that complete bone division has occurred, the frame segments can be separated temporarily by removing the bolts at the base of the aluminum tube and slightly rotating one ring with respect to the other. These bolts are replaced after such confirmation has been achieved.



Post-Operative Adjustments

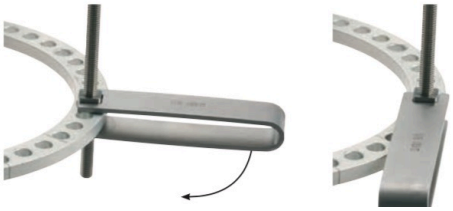
The initiation, rate, and rhythm of distraction are performed according to the surgeon's preference, and by the clinical situation. The patient affects the prescription by turning the square plastic bushing with a 10mm wrench.

Distraction of connected ring segments, and the associated limb lengthening, is achieved by rotating the plastic bushing by the prescribed amount. Each quarter revolution (90° turn) of the plastic bushing results in 0.25mm of distraction. No other manipulations are required.

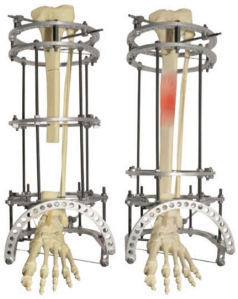
During lengthening, periodic x-rays should be studied to determine the length of the threaded rod remaining within the aluminum tube. Alternatively, the threaded rod may be viewed through a small hole in the aluminum tube at the base of the plastic bushing. **The linear distractor should be replaced with a longer size whenever the threaded rod has reached the level of the hole in the aluminum tube.**

When using the linear distractor to provide compression, the linear distractor should be replaced with a shorter size whenever the threaded rod is visible in the hole at the base of the tube.

SEGMENTAL BONE TRANSPORT



TK-Ring square distraction nuts may be used for segmental axial bone transport. The limb is stabilized in a circular external fixator and a smaller segment of residual bone is transported within the limb until the defect has been traversed. The proximal and distal bone fragments may be fixed to rings with wires and half pins.



A

The transport segment is separated from the host segment and attached to a transport ring with wires or half pins (A). Four threaded rods pass through each ring and are locked to the proximal and distal rings with standard metal nuts and the transport ring with square distraction nuts.

Bone transport is achieved by rotating the square distraction nuts. Each 90° rotation produces 0.25mm of axial bone transport. Repeat the distraction process per the surgeon' s prescription until the transport bone segment reaches the target bone segment **(B).** At this time, the bone ends at of the docking site are prepared for bridging per the sur- geon's preferred technique. Compression between the transport and target segments should be performed to help effect bony union.

B

END.

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