Crossed-pin Technique In Management Of Complex Tibial Fractures

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CROSSED-PIN TECHNIQUE IN MANAGEMENT OF COMPLEX TIBIAL FRACTURES
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INTRODUCTION

This paper considers a method of treatment of complex tibial fractures which requires little armamentarium. The method's chief usefulness lies in the management of tibial fractures accompanied by severe instability and severe soft tissue injury. The technique is called the crossed-pin technique.

The crossed-pin technique is not original with the writer. It has not been described in the literature, although techniques which resemble it are on record. The writer acquired the technique from J. D. Godfrey, M.D. of Buffalo, New York. While reference to a similar technique attributed years ago to Dr. Steindler of Iowa City appeared in a state medical journal, the reference could not be found in that journal or its neighboring issues. In any event, the technique is not original, has not been published but is in use by occasional surgeons throughout the country. The Stader and Roger-Anderson techniques are developments of the basic crossed-pin idea. In the past, all three of these techniques (the crossed-pin, Stader, and Roger-Anderson) have suffered unjustly and badly in reputation due to misuse, usually consisting of short-cuts which circumvented certain necessities inherent in the use of the techniques. For this reason the writer wishes at this point to fix firmly in the reader's mind that the techniques described, while inherently simple, is accompanied by considerable risk if the "Don'ts", which are an essential part of the technique, are disregarded. There is no leeway in these "Don'ts".

The writer's personal experience with this technique will be summarized later. It includes 43 injured legs which contained over 120 fractures. Three-fourths of the legs contained compound fractures and one-fourth contained additional serious loss of bone and soft tissue.

Crossed-pin technique

This technique will be presented as a series of steps.

1. The first step is the proper treatment of all open wounds and damaged soft tissues. Since the indications and methods for this phase of the management are standard surgical procedure and not germane to the main thesis they will not be elaborated.

2. The basic idea of the crossed-pin technique is to drill two Steinman pins in the proximal fragment and two in the distal fragment of the tibia, the pins in each fragment being oriented at 90 degrees to each other and all pins being drilled through the near cortex but not drilled completely through the far cortex. They are simply toed into the far cortex for suitable anchorage. They are usually drilled proximal and distal to the fracture hematoma, not through the fracture hematoma. The pins used must be 1/8 inch in diameter or larger and should have the drill point rather than the stylet point on them. (Fig. 1).

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Figure 1

The stylet pointed pins should not be used to drill through thick, cortical bone. The point acts as a wedge and tends to split the bone. Terrific frictional heat is produced when drilling this point through cortex. The heat literally cooks the surrounding bone and soft tissue.

The drill point cuts its way through cortex and is therefore the more satisfactory of the two points.

The pins are drilled through bone through a small ¼ inch stab wound after suitable local skin preparation. The usual arrangement of the pins is demonstrated in the illustrations. (Figs. 2, 3).

3. After the pins are in place, sterile dressings are impaled upon them and worked down to the skin to keep the unsterile cast padding away from the wounds. If the cast is to be applied while simultaneous os calcis traction is being applied, insertion of the Kirschner wire in the os calcis is done at this time. Os calcis traction has not been necessary in most of the writer's cases because of the unique suitability of the crossed-pin technique for precision wedging.

4. The cast padding is then applied and must be for a long leg cast with the knee in 30 or more degrees of flexion with the cast extending to the groin. Since this cast is worn for ten to twelve weeks, the first layer may be stockinette which will avoid wadding up of the padding over time. About this time (before if stockinette is used) the pins should be cut off, leaving approximately two inches protruding out of the skin.

5. A loosely compacted wad of padding approximately 3/4” in thickness should be fashioned in such manner that it completely pads the anterior surface of

(a)—The stylet point requires too much force to drill through cortical bone, produces too much frictional heat which bakes surrounding tissue and in addition may split a fragment, producing an additional fracture, due to its wedge effect.

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Figure 2
Cross section of leg, diagrammatic, with pins in the tibia. The pins are toed into, but not drilled through, the second cortex. The extra padding between cast and shin — depicted diagrammatically at the top — protects the skin from slough after wedging.

the tibia between the two sets of pins. (Figs. 2, 5). This protects the skin from pressure by the edges of the cast following wedging and failure to incorporate this extra padding in the cast may lead to a slough. When in doubt about the safety of the skin after wedging, inspection of the lateral x-ray will reveal the relationship of skin and cast satisfactorily.

6. The leg is now dropped over the edge of the operating table and while an assistant holds the toes, plaster is wrapped on from the tibial tubercle to the toes, incorporating the pins. Additional plaster as needed is wrapped over the tops of the pins so that all metal is covered. The plaster must be well molded around the pins so there is no play between pin and cast. At least an
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inch of pin and preferably an inch and a half should be so incorporated in plaster. Placing corks or other such devices on the ends of the pins defeats the underlying purpose, which is to rigidly attach each fracture fragment, via its set of pins, to the cast. The assistant holding the toes should be instructed to let the leg hang of its own weight to avoid posterior bowing of the fragments and should be shown how to control the torsional relationship of the fragments. Any malposition and malalignment may be corrected by wedging but correction of torsion in addition to position, length and alignment complicates wedging considerably.

7. When the below knee part of the cast is solid, the leg is then elevated by means of sling or held by assistants while the above knee portion of the cast is applied and allowed to set.

8. Correction of position, alignment, and rotation may be done immediately, or several days later, by wedging. Wedging first necessitates accurate AP and lateral x-ray views of the fracture in the cast. The level of the fracture (or, if a segmental injury, of the fractures) is identified on the cast by a circumferential pencil mark. On the anterior aspect of the cast the long axes of the

![Diagrammatic representation of a specific case. The pins are in, cast is on, pins incorporated and capped by plaster. Long leg cast with 30° knee flexion. Lateral view above, anteroposterior below. The dotted lines represent the lines actually drawn on the outside of the cast from the corresponding x-ray views.](image)

Figure 3

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Figure 4

(a) A single, circumferential saw cut at the level of the fracture is made. The shaded area represents the gap that will result when the angulation is corrected. The shaded area does not depict, in this instance, plaster to be removed.

(b) After wedging (correction of angulation and displacement) the fragments are properly positioned and aligned. The wedge is covered by an additional roll of plaster. Wedging is accomplished simply by adjusting the parts of the cast proximal and distal to the wedge cut until the dotted lines are parallel and abut on each other.

Bones as visible in the AP x-ray view are drawn, producing at the circumferential pencil mark the amount of angulation and malposition which is measured with ruler and protractor on the x-rays. Then one similarly duplicates, by drawing on the lateral aspect of the cast, the long axes of the fragments with angulation and malposition as revealed on the lateral x-ray view. At the conclusion of these steps, the cast contains drawn on it a replica of the long axes of the bones exactly as they lie within the plaster case.

9. If distraction or overriding are present the amount should be measured on the x-rays. In the case of distraction, an additional circumferential pencil line separated from the original one by the exact amount of distraction is drawn on the cast. If there is overriding, two or three spacers are made from layers of tongue blades, such that the thickness of each spacer equals the amount of overriding.
10. A circumferential saw cut is now made around the cast so that the proximal and distal portions of the cast are now separated at the circumferential pencil mark and free to shift position, angulate, and twist on each other. Length correction is produced first, the method being to resect a circumferential ring of plaster equal in width to the amount of distraction, or to insert prepared spacers in the circumferential cut to add length. The cast fragments are then manipulated by hand until the lines representing the long axes of the bone fragments abut end to end and are parallel. If resistance is encountered in this procedure, which is often, it is because the fragments catch on each other. Their resistance is transmitted via the pins to the surgeon's hands. By combinations of torsion, angulation, and displacement it will be possible to "get over the hump" and secure proper position and alignment. A four inch plaster roll is then wrapped around the wedged level, allowed to set, and check x-rays taken. If satisfactory, which is usually the case, an additional wedging six inch plaster roll is wrapped around and allowed to set. If additional wedging is necessary the first four inch roll is removed and re-manipulation performed. (Figs. 3, 4).

11. At the conclusion of this procedure proper length, alignment, and position of the fragments have been restored and secure knowledge that the fragments are immobile exists because they are firmly fixed to the cast by the pins. There is no risk of subsequent slipping. This cast remains on for ten or twelve weeks. At the end of that time there is enough union so that danger of subsequent displacement, angulation, and torsion is nil. The cast and pins are then removed and replaced by a closely fitting long leg cast for an additional eight weeks, at which time union is usually solid enough to begin partial weight bearing. In removing the initial cast the pins are extracted merely by twisting off the

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*Figure 5*

The thick, loose wad of padding between the pins is essential to protect the subcutaneous tibial skin from slough after wedging.
end of the plaster covering them and extracting them with pliers. Since the ends of the pins are buried in tissue and are sterile there is no need to expose the skin in removing them. The pins are usually firmly embedded so a stout pair of pliers is needed for their removal.

**CROSS-PIN TECHNIQUE “DON’TS”**

A. Don't use pins smaller than ½ inch in diameter. They are too flexible and will fail to control the fragments, permitting loss of position and angulation in the cast after wedging.

B. Don't use stylet pointed pins. Use only the drill pointed pins. The heat produced in drilling with stylet points cooks a sizable volume of surrounding tissue which subsequently cultivates myriad bacteria and leads to a very “wet” pin tract.

C. Don’t omit the loose padding over the subcutaneous surface of the tibia. If omitted, wedging may produce pressure on the skin and a slough. If inspection of the lateral x-ray after wedging reveals that the skin in the area of wedge is too close to the plaster for comfort, then remove a 4 to 5 inch wide strip of plaster between each set of pins, fill the defect with accurately fitted sheet wadding and cover it over with plaster. This changes the displacement at the wedging line from an abrupt discontinuity to a gradual one.

D. Don't apply corks or other padding to the end of the pins. They must be completely and solidly encased in plaster. Lack of an external plaster cap permits the pins to work out during the subsequent ten weeks so a covering cap of plaster is necessary.

E. Don’t drill the pin entirely through the far cortex. When a pin is mistakenly drilled all the way through both cortices, it usually will migrate, usually deeper into the leg, while the outer end of the pin withdraws from its plaster socket, thus leading to loss of fixation. Occasionally these events lead to sepsis or to a subsequent operation to find and remove the pin. Bending the exposed pin end through a 90 degree angle will prevent migration if both cortices are penetrated.

F. Don’t ever combine this technique with a short leg cast, or a cast with less than 30 degrees knee flexion, or a cast which does not extend to the groin. The interfaces between pin-and-bone and pin-and-plaster will remain solid for a ten week period only if the loads on these interfaces are below a certain limit. Empirically, the protection provided by the long leg cast is sufficient. Empirically, the lack of proper above knee cast extension leads to loose, then wet, and then infected pin tracts with loss of fixation and often mal-union. Pins are like money; not inherently bad; just good or bad according to the use made of them.

G. Don't be afraid to bivalve a cast with crossed-pins in it. It may be bivalved in such a manner that all four pins (or more if the circumstances of the case required it) remain encased in one or the other half-shell. They continue
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to provide fixation. Using this technique and by fashioning plaster outriggers to hold the proximal and distal portions of the cast solidly together, it is possible to combine the crossed-pin technique with subsequent soft tissue treatment, such as skin grafting, in the region without loss of efficient fixation.

**DISCUSSION**

1. The writer's personal experience encompasses the use of the cross-pin technique in 43 injured legs which contained over 120 fractures in 36 patients, 7 with bilateral leg fractures. In 32 of these legs, one or more of the fractures were open and in 11 of the legs there was moderate to severe loss of bone, skin, or other soft tissue in varying combinations. Three of the 36 patients died within 48 hours of admission due to other injuries. In the remaining 33 cases there have been no non-unions, no osteomyelitis in pin tracts or in the open fractures, no amputations, one loss of length and two mal-unions. 32 people have been unqualifiedly restored to their pre-injury occupations and social and economic levels. The 33rd patient is now undergoing rehabilitation. The benign healing of severely damaged soft tissues in these cases is impressive. Equally impressive is a series of 30 consecutive cases of compound fractures (most of which were severe, not relatively uncomplicated puncture wounds) which all united and none of which became infected with the use of this technique. The lack of bone and soft tissue infection is even more impressive in view of the fact that more than half of the wounds were severely contaminated due to grinding in of road dirt, industrial waste or clothing.

2. The writer's indications for the use of the crossed-pin technique in leg fractures are as follows:

   (a) Unstable segmental fractures, whether open or closed. ("Unstable" here means proven inability to maintain satisfactory reduction by purely closed means).

   (b) Extremely comminuted fractures, particularly when more than one or 1½ inches in length is so affected, either open or closed.

   (c) Any fracture of the middle three-quarters of the tibia accompanied by such severe soft tissue damage that survival of coverage, blood supply, or motor power is considered endangered and is the primary concern of the injury. In such cases the thorough stabilization of bone provided by the crossed-pin technique is more effective as a soft tissue splint than simple immobilization in plaster.

The crossed-pin technique, in the writer's opinion, has the following advantages:

   (a) Immobilization of the fracture or fractures and soft tissues is nearly as efficient as that provided by a plate. The immobilization of the soft tissue is more efficient than that provided by a simple cast or other methods of treatment which do not use some form of internal fixation.

(b)—The other two cases were among those dying of their injuries within 48 hours.
(b) There is no associated periosteal stripping to delay union and enhance the likelihood of non-union.

(c) The fracture hematoma need not be entered and no hardware is placed in the fracture hematoma. This avoids the risk of operative infection.

(d) Precise and dependable control of position, alignment, length, and rotation is obtained by an essentially closed, and thus safe, method. The immobilization provided is similarly effective and dependable.

(e) The technique is suitable for use when the condition of the skin prohibits open surgery on the fractures, but when some form of operative control and reduction are necessary for optimum result.

(f) A minimum of equipment, tools, and surgical know-how is needed.

3. The reader must not assume from the foregoing that any fractured tibia coming to the writer's hands will shortly bristle with pins. For each case treated by the crossed-pin technique, more than 7 have been treated by closed methods, and one by open methods, the bulk of the latter being either Lottes nails or two screws for use in transverse and spiral fractures respectively. Of the 43 legs, only two were children and in both of these the initial injury was severe enough that primary amputation was considered by others to be the treatment of choice. In children the advantages of secure control of position, rotation, length and angulation over a period of time without open surgery are obvious.

4. The writer has used this technique for 12 years. During that time there have been three complications. One was a skin slough due to inadequate anterior padding, abetted by a severe local contusion from the initial injury; the other two were union in 10° varus of subcondylar tibial fractures, one of them being accompanied by ½ inch of shortening.

5. It should be understood that the crossed-pin technique has no magical properties. The fact that during a 12 year period less than 4 patients a year in a busy orthopaedic practice were treated by the crossed-pin technique adequately demonstrates that it has been used selectively.

6. The average time from injury to first weight-bearing in the series of 33 cases is five months. This is the same as in a recent series of 150 cases of leg bone fractures analyzed at the Henry Ford Hospital by Dr. Jerome Kozak. The present series should be viewed in the light that the majority of them were severe injuries with many extensive comminutions, severe compounding and severe contamination. The 150 cases analyzed by Dr. Kozak were an un-selected, consecutive series, the majority of whom had closed and uncomplicated injuries. In the series reviewed by Dr. Kozak there was an incidence of a little less than 3% non-unions, while in this series there has not yet been a non-union. The writer realizes that as more cases accumulate the first

(c)—Now of Lansing, Michigan.
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non-union will occur, but feels that this should not be blamed on the technique in view of the experience to date.

7. In discussing this technique over the years with colleagues, three objections have been so consistently raised that it is worth mentioning them.

(A) Pin tract infection: This is an almost universal objection raised to the crossed-pin technique. The writer does not know the basis of this feeling but does know that in his 33 cases there have been three "wet" pin tracts (which required a week to close) and one pin tract which required a month to close. The remainder, comprising over 140 pin tracts, closed within two days after pin removal. There have been no ring sequestra (which usually follow the use of the stylet point) and no pin tract osteomyelitis. Wet pin tracts probably result from excessive motion of soft tissues around the pins, and excessive stress on the pins following improper casting or too few pins, leading to gradual working loose at the bone-pin interfaces. The pin is only a form of suture and should be protected from overload in the same fashion that the suture line in a repaired tendon is protected during healing.

(B) Non-union: This is the objection heard next in frequency and comes from those colleagues who feel that the physiologic bone absorption at the fracture line results in distraction and this in turn must result in non-union. In the cases described there have been no non-unions in spite of the fact that the majority of these cases had severe injuries. The efficient fixation secured with the crossed-pin technique is probably more important to fracture healing than physiologic bone resorption is detrimental to it.

(C) Fracture infection: This, the next most common objection raised in the crossed-pin technique, is most mysterious since one of the basic features of the technique is that the surgeon is enabled to bypass the fracture hematoma completely! Thirty legs treated, containing compound fractures without subsequent infection, speak eloquently. It is worth noting an additional feature of the technique: a compound fracture which is unfixed, except by a plaster cast, has some motion at the fracture due to the shift in gravity and the pull of the various muscles at the proximal and distal joints as the patient is lying in bed, and particularly as he starts to get up on crutches. This motion is sufficient, in the writer's opinion, to impair soft tissue healing slightly and to increase the susceptibility of the tissues to infection during the first few days after injury.

CONCLUSION

A crossed-pin technique is described for managing complex, severe, tibial fractures, whether open or closed. The technique has the advantage of precise control of reduction, efficient splinting of bone and soft tissue, and surgical avoidance of fracture hematoma and periosteal stripping. The technique in toto is safe and reliable. Like asepsis, how-
ever, it involves a ritual, and *any break in the ritual attendant to it may be dangerous.* The writer believes that the technique is among the most simple and effective presently available in treating extensively compounded, comminuted and segmental fractures of the leg. It is particularly applicable to such fractures when accompanied by severe soft tissue damage. The technique has the advantages of simplicity, efficiency, a minimum of instrumentation, devices, and tools necessary; safety from operative infection and a minimum of surgical know-how necessary for its use.

The technique has the disadvantage, in the writer’s opinion, that it requires more fussiness on the part of the surgeon, and often more time, than other methods.

**Figure 6**

A 54 year old man pinned against a brick wall by a car. The driver stepped on the accelerator instead of the brake. Both bones both legs fractured, closed. Right leg treated by crossed pin technique; union and weight bearing in 4 mos.

Left leg is illustrated. Severely comminuted fracture. Pulseless foot and rapid, tremendous swelling proximal leg and knee. Arteriogram reveals occlusion of posterior tibial artery. This was explored and ligated. Partial weight bearing 5 mos., full weight bearing 7 mos. Returned to job as mechanic 10 months.

6A—Original AP and lateral views left leg; the arteriogram is illustrated on the left.
6B—AP and lateral in cast with pins in place. Note that one of the proximal pins pierces the posterior cortex. This pin drifted deeper into the leg, with loss of one plane of the proximal fragment’s fixation.

6C—Result at 6 mos. when bearing partial weight. The slight shortening and varus were the result of drift of one proximal pin.
A 55 year old man. Compound, slightly comminuted fracture both bones right leg. The original displacement was severe. The entire distal 7 cm. of the proximal tibial fragment was completely stripped of muscle and fascial attachments and was extruding through the skin on admission to the emergency room.

Treatment: Debridement, primary closure, crossed pins.

Partial weight bearing 4 mos. Return to usual work 6 mos.

7A—Original x-rays — after leg aligned in E. R.
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7B—In cast with pins, post wedging. 2 weeks.
7C—One year post injury. There was no infection.
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Figure 8

An 11 year old boy, Pedestrian hit by truck, right front wheel. Wheel was locked, leg caught in wedge between wheel and road and ground to mince meat over a 10 foot skidding distance. Compound fracture both bones leg with some of proximal part of distal fragment ground off. This is visible as a bevel on left side of tibia, right half of 8A. Soft tissues so badly mangled amputation was nearly done. Nerves damaged, road dirt ground into posterior tibial nerve, artery vein. Medial half of gastroc and soleus ground off. Part of medial malleolus ground off. Enormous full thickness skin flap extending from ankle joint line to patella and involving slightly more than half the circumference of entire leg.

The gamble was taken. Extensive debridement, loose suturing skin, crossed pins, long leg cast, antibiotics. The limb survived. Wound edge sloughs granulated in by the time fractures healed. Partial weight bearing 4 mos. Full weight bearing 5 mos. Last x-ray follow-up at 8 mos., last clinical follow up at 18 mos.

End Result: Normally functioning extremity. No infection at any time.

8A—Original films in E. R. About 6 cm. each of proximal and distal fragments were bare and periosteum ground off.
Frost

8B—2 weeks post injury. In cast with pins.
8C—8 months after injury. No infection, normal function, some calf atrophy. The atrophy disappeared in the following 10 months.
Frost

Figure 9

A 45 year old man. Leg sticking out of car window, sideswiped by another car. Comminuted fracture both bones left leg. An open fracture with 7 separate skin lacerations. When explored most of following muscles severed completely by the sharp bone ends: soleus, posterior tibial, anterior tibial, flexor hallucis longus. Neurovascular structures intact (!). Debridement, exploration, repair of motors, crossed pins. Partial weight bearing 5 mos. Full weight bearing 7 mos. Back at regular job on assembly line. Still leaves legs sticking out of windows. Normal function of extremity at 10 months.

9A—Original AP and lateral views.
9B—Lateral view in cast with pins before wedging.

9C—Lateral view after wedging. It required 2 wedges to achieve this position alignment, and length.
9D—AP and lateral views at 6 months post injury. No infection.

9E—AP and lateral views of the cast with buried pins 2 weeks post injury.