ABSTRACT: A modification of the closed intramedullary nailing technique of Kuntscher was used in 102 femoral shaft fractures over a 30 month period. In the technique described here, the Schneider intramedullary femoral nail is used instead of the hollow cloverleaf Kuntscher nail, and the femoral canal is reamed only to 12 millimeters instead of the 16 to 20 millimeters recommended by Kuntscher. As with the original closed Kuntscher technique, this method has been applied to a broad variety of femoral shaft fractures including grossly comminuted, segmental, and eccentrically situated fractures. Despite the inclusion of these difficult-to-treat fractures, the complications have been few, blood loss has been minimal, and healing of the fractures with early abundant circumferential callus has been noted. The authors believe that the closed technique in treatment of femoral shaft fractures is the treatment of choice and have used the Schneider nail because it can be used with rather limited reaming of the medullary canal, and is less apt to bind in the femoral canal. Although the technique of insertion differs from the open technique, the nail itself can be used without modifications.

Open intramedullary nailing of femoral shaft fractures was introduced by Hey Groves in 1918, but his efforts were thwarted by the imperfections of metals available in his time. In 1940, following the development of inert alloys, Kuntscher introduced the closed technique of intramedullary nailing of femoral shaft fractures using a hollow, cloverleaf shaped rod. He further refined the technique through the use of larger diameter rods and aggressive reaming of the femoral canal (at times up to twenty millimeters) thus broadening the indications for its use to include many fractures, not only in the midshaft, but also in the proximal and distal thirds of the femoral shaft. However, this technique did not become popular until the more recent development of a mobile fluoroscopic image intensifier and an extension fracture table that would allow its unobstructed use. Since then a number of authors have reported their experiences with the closed Kuntscher method.

The purpose of this paper is to report a series of cases treated at the Valley Medical Center in Fresno, California, wherein the closed Kuntscher technique has been modified in two ways, i.e., using a solid nail (the Schneider intramedullary nail) rather than an open cloverleaf type, and more limited reaming of the femoral canal than that used in the Kuntscher technique.

Clinical Material

This is a study of intramedullary fixation of femoral shaft fractures over the 30 month period, October, 1977 thru April, 1980. There were a total of 102 fractured femora in 98 patients (four bilateral). The first closed nailing of the femur was performed at the Valley Medical Center in October, 1977. As proficiency and confidence in the method increased, so did the proportion of closed nailings versus open nailings. During 1978, for instance, 23 of 39 femoral fractures (59%) were treated by closed nailing, while in 1979, 60 of 63 fractures (more than 95%) underwent closed nailing. Some of this increase in the total number of closed operative procedures represented the addition of severely comminuted and/or eccentrically located fractures that would not have been amenable to the open technique. In the closed nailing group there were 81 males and 17 females. The patient's ages ranged from 15 to 79 years. The great majority, 79 patients
(80%), were in the 16 to 30-year old group. Twenty-one patients had other injuries to the same extremity including nine with both bone fractures of the lower leg, three with fractures of the femoral neck, five with fractures of the acetabulum, one with a dislocation of the talus, and two with traumatic amputations. Fifty-two of the patients (53%) had significant injuries other than in the limb with the fractured femur as exemplified by one patient who sustained a traumatic amputation of the foot necessitating a below the knee amputation, a ruptured spleen, fractures of the humeral shaft and a segmental fracture of the ulna. Ten of the fractures were open injuries including four gunshot wounds. These were nailed when it appeared that the wounds were healing with healthy granulation tissue (usually within seven to ten days). One of the gunshot wounds was nailed on the day of injury so as to facilitate repair of an associated arterial injury. Seventy-seven percent of all fractures were nailed within ten days of the injury. The longest delays were 20 and 21 days in two patients with severe and multiple injuries that precluded earlier surgery.

Complications

Complications were few and included shortening in eight extremities. In two cases shortening measured two centimeters, while in the other six the shortening measured less than two centimeters. There were two cases whose femoral fractures had not united when last seen at six and seven months postoperatively, and have since been lost to follow-up. In both of these cases, the fractures were of the comminuted segmental type with inadequate immobilization resulting from the use of too small a diameter nail (nine millimeters). There were two cases of valgus deformity at the fracture site measuring approximately eight degrees each. There were no cases with clinically measurable rotatory malalignment. In one case of pathological fracture, the intramedullary nail migrated proximally and required distal advancement with fixation proximally at the greater trochanter using a screw and wire. On two occasions the fracture was opened after unsuccessful attempts at closed nailing. One of these occurred early in the series and involved a fracture at the subtrochanteric level of the shaft where the operator did not appreciate the acute flexion of the proximal segment, causing the guide wire to be repeatedly driven through the trochanteric region posterior to the medullary canal. The other involved a long, oblique fracture at the junction of the middle and lower thirds of the shaft that could not be reduced by the closed method. Muscular interposition was the underlying cause. There was one case of postoperative atelectasis, and one case of pulmonary fat embolism occurring 48 hours after the fracture and 24 hours following the closed nailing. There were no deaths, wound infections, nail breakage, or bending of the nail.

Technique

On admission, the involved extremity is placed in balanced skeletal traction through the proximal tibia to await surgery. Traction ranges from 20 pounds in a petite female to 35 pounds in the above average male. Traction of this magnitude facilitates the subsequent closed nailing and is especially important where the patient’s general condition precludes surgery within the first few days following injury. In 77% of our cases, surgery was performed within the first ten days. Under general anesthesia the patient is transferred from his bed onto the fracture table and placed in the lateral-decubitus position with the fractured extremity uppermost. Preliminary reduction is accomplished by traction through the foot piece of the fracture table, allowing the foot to rotate internally (usually to neutral). The hip of the fractured extremity is usually placed in 30° of flexion but this is increased in the more proximally situated fractures so as to align the distal fragment with the short, flexed, proximal fragment. The opposite hip is placed in full extension thus permitting an unobstructed lateral fluoroscopic examination of the fractured femur (Fig. 1A, B). Fluoroscopic examination in the anteroposterior and lateral views is performed, and any adjustments in limb position or amount of traction are than made. The operative field is then draped to permit free and aseptic access with the fluoroscope during the procedure, and to permit opening of the fracture if the attempts at closed nailing are unsuccessful.

Surgery is performed through an incision beginning at the tip of the greater trochanter and extending proximally three or four inches in line with the femoral shaft. In obese patients the incision must be extended more proximally so as to permit a straight line introduction of the guide wire into the medullary canal and thus avoid penetration of the medial femoral cortex. The superior aspect of the cervical-trochanteric junction is exposed by splitting and spreading the gluteus maximus and medius muscles in line with the skin incision. A sharp, curved awl is introduced into the trochanteric fossa at the cervico-trochanteric
junction and driven two or three centimeters into the medulla of the femur with a twisting to and fro rotatory motion (Fig. 2A, B). The position and direction of the awl should be monitored with fluoroscopy. A one meter long intramedullary guide wire is then introduced into the aperture created by the awl and driven down to the fracture site. In most cases, only the proximal fragment needs reaming. However, if the fracture is proximal to the isthmus of the femur, the distal segment must also be reamed. In such cases, the guide wire is passed into the distal segment after reaming the proximal segment.

Frequently, introduction of the guide wire into the distal segment requires manipulation of the fracture. Control of the proximal fragment is facilitated by threading a nine millimeter in diameter Krötscher nail over the guide wire in the previously reamed proximal fragment and using this as a handle to align and proximal femur with the distal fragment. Occasionally, the distal fragment will also require manipulation. The surgeon can use a “pusher instrument” such as a repair of large Lane bone holding forceps clamped to one another at their jaws to apply pressure over the posterior thigh. If necessary, pressure over the anterior or medial aspect of the thigh can be applied by an unscrubbed assistant using a shortened crutch or similar instrument beneath the sterile drapes. Reaming is continued with the flexible reamer, progressing in one millimeter increments to 11 millimeters in the adult female and 12 millimeters in most adult males. The diameter of the Schneider nail to be introduced should equal the diameter of the last reamer used. Its length should have been determined preoperatively by tape measurement of the opposite femur. The nail should be bent to conform to the natural anterolateral bow of the femoral shaft. After the nail has been driven into the distal segment a distance of three or four inches, careful monitoring using the AP fluoroscopic projection is necessary to insure central advancement of the nail to and through the distal ossified epiphysial plate. Frequently, crutch support beneath the fracture site, especially in the more distally situated fractures, is necessary to preclude valgus deformity at the fracture site. Traction is then released, and a final check of the reduction is made.

The average anesthetic time has been 75 minutes and the average operative time has been 50 minutes. Operating time ranged from 25 minutes in a simple transverse mid-shaft fracture to 95 minutes in a severely displaced segmental fracture. Blood loss has
ranged from 50 cubic centimeters to 200 cubic centimeters with the average about 100 cubic centimeters. Radiation exposure is greatly reduced with the use of the image intensifier. Still images are obtained by using the "recording mode" technique rather than the continuous fluoroscopic technique. Two exposures (AP and lateral) are taken just prior to surgery and about ten more exposures are taken intraoperatively. All operating personnel wear lead aprons and stand away while the fluoroscope is being used.

Postoperatively, the extremity is suspended in a Thomas splint for a few days. The patient is then ambulated with crutches or walker, permitting partial weight bearing on the involved extremity as tolerated. Progression to full weight bearing has occurred as early as six weeks in some cases and by four months in most cases. In comminuted fractures where there is a possibility of shortening or rotatory deformity, skeletal traction with 15 pounds is continued postoperatively in a Thomas splint and Pearson attachment for 12 to 21 days. Touchdown weight bearing is permitted when ambulation begins, but full weight bearing is not permitted for three months postoperatively.

**Case Reports**

Case No. 1: A twenty year old male motorcyclist crashed into an automobile at high speed and sustained a comminuted fracture of the middle third of the left femur (Fig. 3A) with a small "penetrating from within" type wound over the medial aspect of the thigh at the fracture site. There were no other significant injuries. Initial treatment consisted of debridement and dressing of the thigh wound followed by application of 30 pounds of skeletal traction through the proximal tibia. Five days later, with his condition stable and the wound showing healthy granulation, a closed intramedullary nailing of the femur was performed using a Schneider intramedullary rod 42 centimeters long by 11 millimeters in diameter. Because of the degree of comminution at the fracture, ten pounds of skeletal traction was continued for two weeks postoperatively. Ambulation on crutches was then begun along with mobilization exercises to regain motion at the knee. At the clinic two weeks later; one month postoperatively, abundant callus was seen (Fig. 3B). The patient was instructed to increase weight bearing on the involved extremity to tolerance. At two months postoperatively he was walking without support and without apparent discomfort. He did display a mild lurch and one-half inch of shortening. At six months postoperative there was solid union of the fracture (Fig. 3C) with a full range of motion at the knee and the hip. His gait was normal using a three-eights inch heel lift.

Case No. 2: A twenty-one year old male sustained multiple gunshot wounds to the head, chest, abdomen, and left thigh. X-rays revealed a comminuted fracture of the femoral shaft at the isthmus (Fig. 4A). The pulses at the foot were present, but weak. Arteriography suggested injury to the superficial femoral artery in the region of the fracture. Following
laparotomy to repair a tear in the sigmoid colon, the fracture of the left femur was stabilized by the closed intramedullary nailing technique using a Schneider intramedullary rod 40 centimeters long and 11 millimeters in diameter (Fig. 4B).

This was followed by exploration and repair of the injured artery. Skeletal traction (ten pounds) was employed for three weeks postoperatively because of the severity of the comminution which could lead to shortening and/or rotatory deformity despite the intramedullary rod fixation. His wounds healed per primum and his postoperative course was uncomplicated. He discarded one crutch two months postoperatively and the other crutch at three months. The patient had full motion at the hip and knee and he had three-eighths of an inch shortening of the left leg. X-

Fig. 3A: Case No. 1: D.W. Long oblique fracture with large butterfly fragment.
Fig. 3B: Case No. 1: D.W. One month post closed nailing. Note abundant early callus.
Fig. 3C: Case No. 1: D.W. Six months postop showing mature callus and remodelling.
rays at six months post-injury revealed a solid union (Fig. 2C, 2D).

**Discussion**

Closed intramedullary nailing is our treatment of choice for most fractures of the femoral shaft involving adults and skeletally mature adolescents. Proximally, we have included even the subtrochanteric fractures provided there is an intact posterior cortex extending at least two inches distal to the lesser trochanter. Distally, we have treated fractures extending within five inches of the intercondylar notch. But with fractures at this level postoperative traction, for as long as three or four weeks, is necessary to preclude malalignment or malrotation, especially in the comminuted cases. The cast brace was used postoperatively in a few of these patients to permit earlier removal of the traction.

The closed technique described here requires reaming of the medullary canal to only 11 to 12 millimeters as compared to the Kuntscher technique which describes reaming, at times up to 20 millimeters. This obviously simplifies and speeds the operative procedure and to this date has not compromised the clinical results. The solid Schneider self-broaching intramedullary nail is less apt to become incarcerated during its insertion. It is an appliance familiar to the many surgeons presently using it with the open technique and requires no modification when used in the closed technique.

As has been reported, we too have been impressed with the more abundant and more circumferential callus formation in cases treated by this technique. This might be explained by the fact that this is essentially a closed method of fracture reduction and fixation which obviates the need for opening the fracture or stripping of the peristemeum. Iatrogenic devitalization of bony tissue is avoided and the possibility of septic complication is grossly reduced. The roentgenographic evidence of mature bridging callus with partial obliteration of the fracture site is seen as early as six weeks after surgery. Advanced remodeling and almost complete obliteration of the fracture site is usually seen at six to nine months postoperatively. Because we elected to use a nail of lesser diameter than used with the Kuntscher technique, we were reluctant to permit full weight bearing before 10 to 12 weeks postoperatively. However, none of the patients who disregarded this restriction displayed any nail breakage or nail bending. As a result, we have more recently permitted full

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**Fig. 4A:** Case No. 2: J. B. Gunshot wound with severe comminution of the femoral shaft (AP).

**Fig. 4B:** Case No. 2: J. B. Immediate postoperative film following closed nailing of the femur and repair of associated vascular injury.
weight bearing as early as six weeks; again, without untoward effects.

**Summary**

A modification of the Kuntscher closed intramedullary nailing technique for treatment of femoral shaft fractures is described and the results of its application in one hundred and two femora are presented. The operative procedure is rather simple, blood loss and surgical exposure is minimal, and complications have been few. Early, abundant and circumferential bridging callus has been seen to develop, thus permitting full weight bearing as early as six weeks post-injury in some cases, and by four months post-injury in most cases.

**References**
